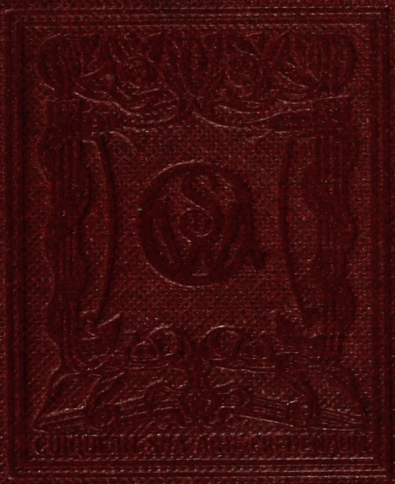

Edw T. Carey

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GUIDE TO ANÆSTHETICS

FOR THE

Student and General Practitioner.

PRINTED BY

WILLIAM GREEN AND SONS

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GUIDE TO ANÆSTHETICS

FOR THE

STUDENT AND GENERAL PRACTITIONER

BY

THOMAS D. LUKE, M.D., F.R.C.S. (Ed.)

LECTURER ON ANÆSTHETICS, EDINBURGH UNIVERSITY, ANÆSTHETIST TO THE DEACONESS HOSPITAL, AND THE DENTAL HOSPITAL, EDINBURGH

WITH 43 ILLUSTRATIONS

FOURTH EDITION

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BY THE SAME AUTHOR

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Dedicated

TO

SIR J. HALLIDAY CROOM, M.D., F.R.C.S.Ed.

PROFESSOR OF MIDWIFERY IN THE UNIVERSITY OF EDINBURGH

in grateful acknowledgment

OF MANY ACTS OF KINDNESS

PREFACE TO THE FOURTH EDITION

THE favourable reception afforded this little work, both in this country and in the United States, has made it possible to bring it more completely up to date in a further edition. No department of medicine stands still in the present day, and that of anæsthesia is no exception to the rule. Various minor changes in the text have been made throughout, and the question of acetonæmia has been more fully considered.

The subjects of local, regional, and spinal anæsthesia have been dealt with at greater length, and I have been fortunate in being able to hand this whole section over to the care of my friend Mr. W. J. Stuart, Assistant Surgeon to the Royal Infirmary, Edinburgh. At the present time, a surgeon has naturally a good deal more to do with these methods than an anæsthetist, and any conservative statements on their employment and value, coming from the former, cannot be fairly attributed to any professional bias. It is perhaps not unnatural that the ordinary anæsthetist is not, at the moment, inclined to be enthusiastic on any rival to anæsthesia by inhalation. Thanks are due to Dr. L. R. H. Marshall for the care with which he has revised the proof sheets, and as before I beg to express my obligation to the various instrument makers for the loan of blocks. In this connection, it is only right to mention that Fig. 17 is the copyright of Messrs. G. Barth & Co.

THOMAS D. LUKE.

EDINBURGH, *October* 1908.

PREFACE TO THE SECOND EDITION

THE advent of ethyl chloride as a general anæsthetic has necessitated an almost complete re-writing and re-casting of several portions of this little book to bring it up to date. During the past two years this drug has made enormous strides in this country, and bids fair in a few years to be the most frequently employed anæsthetic which we possess. It has almost completely displaced nitrous oxide as far as general surgery is concerned, although this anæsthetic will probably continue to be employed in dentistry.

My thanks are due to Messrs. Down Bros., Arnold & Son, Barth & Co., and others, for kindly lending electros for purposes of illustration.

While the book has not been enlarged to any extent, my endeavour has been within a comparatively small compass to give a fairly comprehensive account of the practice of anæsthetics at the present day, such as I trust may be intelligible and serviceable to the general practitioner and student.

THOMAS D. LUKE.

EDINBURGH, *October* 1904.

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CHAPTER I

INTRODUCTORY

THERE are few subjects to which a student gives less attention during his curriculum than that of anæsthetics. As Sir Frederick Treves has said: "There is a widespread impression that to give chloroform is a minor act—that the power comes with the granting of the diploma—and the significance of the procedure is sometimes emphasised by the remark, 'Well, if a man cannot give chloroform, what can he do?'"

From some of our schools men are sent out year after year, absolutely ignorant of the elementary principles of anæsthetic administration, or, at the most, with a very imperfect knowledge of one anæsthetic—usually chloroform. Can we wonder that the mortality under anæsthetics at the present time is a very heavy one? For this state of matters the councils of some of our universities and licensing bodies are responsible. Two of these, however, have recently made it compulsory for students, desirous of their diploma, to present a certificate showing that they have received proper instruction in the use of the various anæsthetic agents, and it is to be hoped that very soon some of the older and long established bodies will follow their good example.

No one anæsthetic can possibly be universally adopted if the best results are to be obtained; and while fully alive to

the difficulty of men in general practice, long past their student days, rendering themselves familiar with the use of inhalers for ether and other comparatively safe anæsthetics, we cannot help feeling that, in certain parts of Great Britain, chloroform could frequently be replaced by one of these safer agents, with advantage to both doctor and patient, and that the greatly increasing mortality from anæsthetics is largely due to the indiscriminate, not to say reckless, use of this

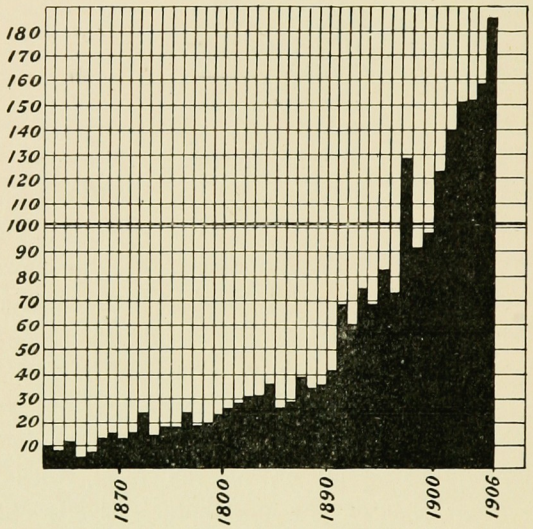


Fig. 1.—Diagram of the annual numbers of "deaths from anæsthetics" in England in the years 1863 to 1906, constructed from the returns of the Registrar-General.

invaluable but lethal agent. It has been recently pointed out that the anæsthetic mortality has more than doubled during the last ten or twelve years.

In regard to this striking diagram, Professor Waller says,* "The unsifted figures of such returns are not, I am aware,

* *Lancet*, 28th November 1903.

unimpeachable scientific evidence of the number of deaths caused by anæsthetics.

"The numbers may be too high or too low; they may include cases not caused by anæsthetics, but that have occurred from other causes during anæsthesia; or they may fail to include cases of death really caused by anæsthetics, but certified, and quite honestly certified, as caused by that disease for which the services of the surgeon and the anæsthetist have been invoked. I think, however, that the returns are sufficiently voluminous to be amenable to the 'law of large numbers,' and to justify us in regarding the actual figures, inclusive of their plus and minus errors, as fairly representative of the state of the case as regards the death-rate from anæsthetics in past years. The figures are at least arranged by an unprejudiced machinery, and I cannot but regard as disingenuous the assertion that such figures are worthless, and the demand for their detailed analysis. Detailed analysis is impossible, and, even if possible, would be misleading, for if faults of commission might be detected, faults of omission might be beyond correction."

Ether and chloroform have, since their introduction, been rivals for the surgeon's favour, and each in its turn has taken the premier place, at different periods, almost all over the world. Chloroform has nearly always been more popular in tropical countries and in Scotland—the land of its birth. Endless, and often not very profitable, discussions have taken place as to which was the better anæsthetic, and after about half a century of such controversy we have fairly come to the conclusion that each anæsthetic has its place, that the man who is familiar with the use of both is in a better position to obtain good results than he who is only acquainted with one, and that in regard to all anæsthetics much more depends on the skill and experience of the administrator than on the nature of the anæsthetic or inhaler used.

The position of the general practitioner as regards the

administration of anæsthetics has been admirably summed up in the following words * :—

"If medical men were well educated in the theory and practice of anæsthesia, they would recognise for themselves that for nose and throat operations, associated with severe hæmorrhage, for cases where the breathing is embarrassed by aneurism or tumour, or for prolonged abdominal operations, the administration of the anæsthetic should be intrusted to those who have given more than ordinary time and attention to the subject. The satisfactory administration of anæsthetics in many cases of disease—*e.g.* empyema—is fraught with risk. Safety to the patient and comfort to the operator can only be insured by long experience, caution and skill. It is quite impossible to suppose that all medical men can be educated to such a high pitch of excellence. They should, however, be enabled during their hospital career to attain a sufficient knowledge to fit them to estimate the limit of their own capabilities, and to know when a given case is difficult or dangerous.

"In districts remote from large cities, it is the duty of every man bravely to encounter difficult and dangerous cases, and do his best by them.

"If once the young practitioner grasps the fact that every case of anæsthesia is a study in itself, in the selection of the appropriate agent for safety and for the operator's convenience, fully appreciating that every case has its peculiar risks and after dangers, he will continue to improve as years advance. At all events, his medical teachers will have done their duty by equipping him as well as possible for one of the most important after duties of his professional life."

The Relative Mortality under the various Anæsthetics.

The safest anæsthetic of which we know at the present day is nitrous oxide, the death-rate of which is given by Buxton

* Mr. Marmaduke Shield in *Practitioner*, October 1896.

as 1 in 100,000; but we can only regard this as a nominal death-rate, for it must be considerably less. We are safe in saying that this anæsthetic has been administered on many million occasions, and only thirty-five deaths have been recorded during the past half century. We find that the death-rate under the various anæsthetics is as follows:—

Nitrous Oxide	1—100,000 (?)
Ethyl Chloride	1— 12,000
Ether	1— 10,000
ACE * and CE .	1— 7,500
Chloroform . . .	1— 1,000

An immediate deduction is to be drawn from these figures, which should be applied in practice, with the object of reducing the excessive number of fatalities which, as we have shown, at present occur under anæsthetics. This obvious deduction is that some of the known anæsthetic agents are less likely than others to act in a toxic manner on the human organism, and *we are surely bound to use the safest anæsthetic which we possibly can for any given operation*, taking all the circumstances of the case into consideration.

This should certainly be made a working principle, and a few instances will illustrate this point. We have no right whatever to give chloroform to a patient who puts himself trustingly into our hands for the extraction of a few teeth, if nitrous oxide gas, or ethyl chloride and ether, are available. Similarly, if a patient is to be curetted, and there is no contra-indication to ether, we are in duty bound to administer this anæsthetic, or at any rate CE mixture, in preference to pure chloroform. At the same time, unreasonable or unreasoning bias is to be avoided, and if an operation on the brain or about the face is to be performed, we are equally bound to administer chloroform, as in this case *the immediate necessities of the operation* must be foremost in our mind, and the high death-

* ACE is a mixture of alcohol 1 part, chloroform 2 parts, ether 3 parts. CE is a mixture of chloroform 1 part, and ether 2 parts.

rate from chloroform must not make us frightened to use it, where there is such a clear indication.

Summary of the History of Anæsthetics.

1798. Sir Humphry Davy cut a wisdom tooth under nitrous oxide.

1842. Dr. Crawford W. Long, Georgia, U.S.A., gave ether with success for some surgical operations.

1844. Horace Wells, Hertford, Connect., gave nitrous oxide for dental extractions, and attempted publicly to demonstrate its action, but the demonstration was a failure.

1846. Mr. W. T. G. Morton (dentist), pupil of Wells, on Jackson's suggestion, used ether with success for dental extractions, and, on 17th October of same year, for a surgical operation at the Massachusetts General Hospital—Dr. Collins operating. The first operation under ether in an English hospital took place at University College Hospital on 21st December of this year, Mr. Squire giving the ether and Mr. Liston operating.

1847. Sir J. Y. Simpson employed ether for first time in midwifery practice on 19th January; later in same year he introduced the use of chloroform for anæsthetic purposes.

1848. 28th Jan.—Hannah Greener, the first victim to chloroform, died at Winlaton, near Newcastle, Dr. Meggison being the chloroformist.

1858. Dr. John Snow's classical work "On Chloroform and Other Anæsthetics" appeared.

1868. Dr. Evans demonstrated the value of nitrous oxide at the London Dental Hospital.

1877. Dr. Clover invented his portable regulating inhaler —the most valuable anæsthetic mechanism ever introduced.

1879. Glasgow Committee of British Medical Association met, and condemned the use of chloroform.

1889. The first Hyderabad Commission met.

1890. The second Hyderabad Commission met, and concluded that "chloroform was a comparatively safe body, used properly."

1901. The British Medical Association Committee published a fresh report, again condemning the indiscriminate use of chloroform.

1902–6. The introduction into general use in the United Kingdom of ethyl chloride as a general anæsthetic.

CHAPTER II

THE CHOICE OF THE ANÆSTHETIC

THE choice of the anæsthetic is influenced by the following factors :—

(1.) The type and condition of the patient.
(2.) The age of the patient.
(3.) The nature of the operation.
(4.) The skill of the administrator.
(5.) The wishes of the operator.

(1.) THE TYPE AND CONDITION OF THE PATIENT.

It is a remarkable fact that an individual whose health is somewhat impaired by disease is often a better subject for an anæsthetic than a person who is in the enjoyment of robust health.

Among the laity there is a widespread impression that, if the heart be sound, all must go well, whereas, in about 90 per cent. of the fatalities under chloroform, at the *post-mortem* examination the heart is found to be perfectly normal. Far more importance must be attached to the nervous disposition and temperament of the patient, and the amount of alcohol and tobacco which he is accustomed to use. A healthy, vigorous male adult is by no means the best subject for anæsthesia in many cases. Although the heart and lungs may be in excellent condition, and able to stand any strain which may be put upon them, yet the subject will not pass so readily and smoothly into the anæsthetic sleep, in most cases, as a less robust type of patient, but will show greater tendency, as a rule, to struggling and excitement, which will interfere with the respiratory rhythm.

Anæmic patients, and the subjects of tubercular disease (if we exclude active pulmonary tuberculosis), are better anæsthetised with ether than with chloroform, *ceteris paribus*, as their blood pressure readily becomes unduly depressed by the latter anæsthetic. If the ether be administered by means of a closed inhaler, however, care must be taken not to accentuate the air deprivation which will be badly borne.

Fat people nearly always give the anæsthetist some trouble when the method employed involves any air limitation, and to fully anæsthetise a fat, short-necked person by means of a Clover's inhaler, without producing undue secretion of mucus and saliva, with accompanying cyanosis, is well-nigh impossible. For this type of patient, therefore, CE mixture or chloroform, given with plenty of air, is indicated.

Edentulous people are sometimes troublesome, owing to the tendency to suck in the lips in a valve-like fashion and obstruct the airway. The anæsthetist should separate the gums and lips with his fingers, and keep them apart by means of the corner of a towel or a small wooden prop.

Patients who have *adenoid growths* and enlarged tonsils are not good subjects for any anæsthetic, and in dealing with them chloroform should, as far as possible, be avoided, especially in the case of children, as the adenoids are often associated with the "status lymphaticus" and persistent thymus gland.

In **Goitre,** angina Ludovici, and any condition involving much constriction of the air passages with accompanying dyspnœa, great care is necessary to use no anæsthetic or method of administration which will in any way hamper the breathing or cause cyanosis. Several deaths have occurred under nitrous oxide and ethyl chloride in such cases. A light anæsthesia under CE mixture is best, but in operations for the removal of enlarged thyroids general anæsthesia is frequently so hazardous that many surgeons (notably Theodore Kocher and James Berry) prefer to operate under local anæsthetics. The existence of active bronchitis (simple

or tubercular), or a marked tendency to bronchial affections, contra-indicate ether.

Some asthmatical patients, however, are in no way adversely affected by the inhalation of ether.

Cardiac Disease.—Patients suffering from valvular disease may take chloroform quite well, often better than ether, but the greatest possible care is requisite both in inducing and maintaining anæsthesia.

In aortic disease and tricuspid disease there is marked tendency to syncope, particularly in the recovery stage.

In patients with **Cardiac Myasthenia,** simple or fatty, in dilatation without hypertrophy, and in disease of the coronary arteries, chloroform is strongly contra-indicated, as is also nitrous oxide. Grave responsibility is incurred in sending the subjects of such pathological conditions to a dentist for the extraction of a tooth under nitrous oxide. The majority of fatal accidents under this ordinarily very safe anæsthetic have occurred in such circumstances.

In conditions of **Renal Inadequacy** both chloroform and ether are to be used with great caution, for ether congests the kidney unduly, aggravating the albuminuria, while chloroform often increases the degenerative changes in the kidney substance; if there be really advanced renal disease, they are both contra-indicated.

Diabetic Patients are bad subjects for chloroform, for, after regaining consciousness, they frequently become comatose and die from acetonæmia.

Insane Patients are not the better of either nitrous oxide or ether, while mental aberration is not unknown after the inhalation of chloroform. Ether is, however, much more prone to induce marked cerebral excitement in these patients.

Chloroform or the CE mixture may be given at almost any period during **Pregnancy** with safety, if ordinary precautions be taken, but if nitrous oxide be administered, care

should be taken not to push it, as marked clonic contractions are to be avoided.

Female patients, if anæsthetised during the menstrual flow, are more prone to excitement and hysterical symptoms.

(2.) The Age of the Patient.

Patients under 5 years of age.—Either pure ether, or CE on a Schimmelbusch mask is to be recommended. Young children are as readily anæsthetised with ether as with chloroform, and it is well to remember, in dealing with them, that choroform is a powerful protoplasmic poison, which may produce marked degenerative changes in the tissues and organs long after the anæsthetic effects of the drug have disappeared.

Further, the condition known as "false anæsthesia" is more frequently seen in children when chloroform is used.

Patients from 5 to 15 years of age.—The CE mixture may here be used with confidence. There is rather a tendency to embarrassing secretion of mucus and saliva with cyanosis and stertor in this class of patient if ether be used.

Patients from 15 to 70 years of age and over.—If there be no respiratory trouble or other contra-indication, ether may be used for such patients as the routine anæsthetic, with every confidence. The CE mixture is an excellent alternative for such patients as do not take ether well.

(3.) The Nature of the Operation.

Cases suitable for Ethyl Chloride or Nitrous Oxide.

(1.) Extraction of teeth.
(2.) Opening superficial abscesses.
(3.) Tenotomies.
(4.) Removal of aural polypi.

(5.) Passive movements of stiff joints.
(6.) Avulsion of toe-nail or finger-nail.
(7.) Removal of external piles.
(8.) Scraping patches of lupus.
(9.) Application of cautery.
(10.) Removal of drainage tube or dressing from sinus, &c.
(11.) Turbinectomy.
(12.) Removal of post-nasal adenoids.

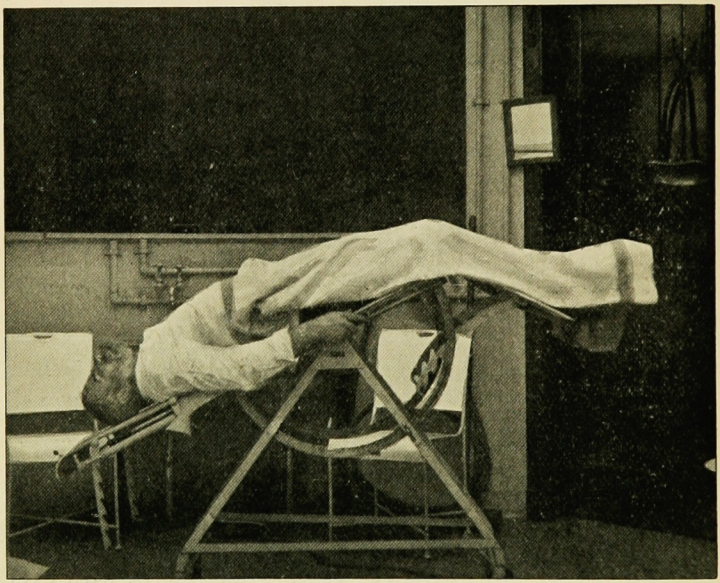


Fig. 2.—the trendelenberg position.

Cases suitable for Ether (which may of course be preceded by N_2O or Ethyl Chloride, with advantage in most cases).

(1.) Operations on extremities, such as amputations, osteotomy, reduction of dislocations, and excision of large joints especially.
(2.) Operations on rectum for piles, fistulæ, stricture or excision.

(3.) Operations on the genito-urinary organs; lithotomy, urethrotomy, castration, amputation of penis, operations for varicocele, nephrotomy, and nephrectomy.

(4.) Many simple hernia operations and colostomies.

(5.) Excision of breast—partial or complete.

(6.) Most ovariotomies, amputation of cervix—vaginal and most supra-vaginal hysterectomies, and curetting always.

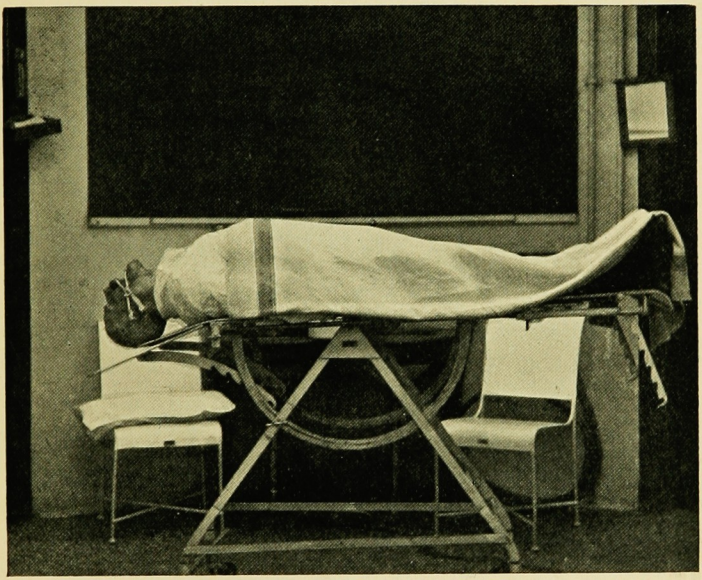


FIG. 3.—ANNANDALE'S POSITION.

(7.) In all conditions of collapse—*e.g.*, after railway smashes, gunshot wounds, strangulated herniæ, and ruptured viscera, and where the patient's vitality is extremely low from cachexia, debauchery, or chronic inanition.

(8.) In all dental extractions of a prolonged kind, for which the period of anæsthesia provided by nitrous oxide and ethyl chloride is too brief.

Cases suitable for Chloroform.

(1.) Operations on the neck—*e.g.*, plastic operations and removal of tubercular glands.

(2.) Intracranial operations.

(3.) Excision of tongue, inferior and superior maxillæ.

(4.) Abdominal operations, when preferred by the surgeon, where the exaggerated Trendelenberg position is used, or the patient breathes too vigorously under ether.*

(5.) In cases of labour, generally speaking, chloroform is most convenient, as the patients usually have vigorous circulations and temporarily hypertrophied hearts, and so bear it well. Fatalities are exceedingly rare, and when they occur are usually due to gross carelessness, or due, perhaps, to the administration of the anæsthetic being handed over to the nurse. Simpson objected to ether for this purpose, owing to the amount needed, and further, owing to the persistence of the odour of the anæsthetic. These objections have since been removed by the introduction of proper inhalers, and in operative midwifery ether or some combination of this anæsthetic with chloroform, such as CE, has much to recommend it.

(4.) The Skill of the Administrator.

The skill of the individual responsible for the anæsthetic, and his familiarity with one anæsthetic agent and ignorance of another, must of course have an important bearing on the choice of the actual anæsthetic used in any case.

* Kocher remarks that "for operations exceeding one hour in duration ether should be used, *ceteris paribus*" ("Operative Surgery," Second Edition. Translated by H. J. Stiles). This, coming from a surgeon of such high repute and large experience, carries great weight, though it is not in accordance with our own practice.

(5.) The Wishes of the Operator.

The wish of the operator, with all due consideration of the patient's condition, &c., should be paramount, for it is obviously unfair to the surgeon and undesirable for the patient that the former should for one moment feel that he is embarrassed in his work in any way.

Further, in some cases it may be desirable to commence with one anæsthetic and continue to maintain anæsthesia with another. Many deaths under anæsthesia have been due to persistence in the use of an anæsthetic which, *to the initiated*, was obviously unsuited for the patient.

CHAPTER III

NITROUS OXIDE, N_2O, PROTOXIDE OF NITROGEN

(Popular Name, "Laughing Gas")

NITROUS OXIDE was discovered by Humphry Davy in 1798, and introduced as an anæsthetic agent in dental surgery by Horace Wells, of Hertford, Connecticut, U.S.A., in 1843.

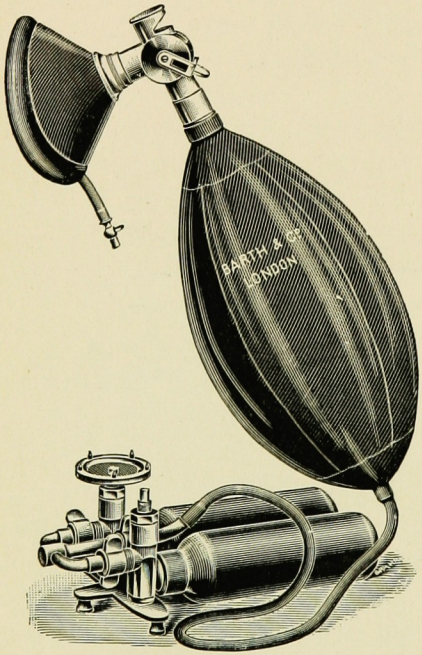


FIG. 4.—BARTH'S NITROUS OXIDE APPARATUS.

The gas is a colourless body, possessing a rather sweet taste and odour, and a specific gravity of 1·527. It is neutral in reaction, and consists of nitrogen and oxygen in chemical combination, and so differs from atmospheric air, which is a simple mechanical mixture of these gases.

The Apparatus for administering is a very simple one. It consists of a face-piece and a three-gallon bag of rubber, joined by a three-way stop-cock and connected by a tube with two steel gas cylinders.

Gas cylinders are of two kinds—

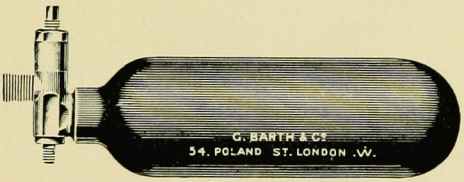
(1) Angle pattern, and (2) Ordinary pattern.

The former is the most convenient kind, as it can readily be turned on and off with the foot when on a stand by one manipulation, and leakage is less apt to occur. These cylinders have to be very strongly made to stand the enormous pressure of the liquefied gas, and are rather costly, but are let out on hire by the makers of nitrous oxide.

They are made in 25, 50, 100 and 500 gallon sizes, but for general purposes the 50 and 100 gallon sizes are most convenient.

FIG. 5.
ORDINARY.

FIG. 6.
ANGLE.



NITROUS OXIDE CYLINDERS.

Formerly dentists used a gasometer for nitrous oxide, but this is seldom used at the present day. The actual technique of the administration with it was even simpler than with the modern apparatus, but the gasometer was more expensive, apt to leak and get out of order, and was the reverse of portable.

Technique of the Administration.—The patient should be seated on a dental chair or an easy chair with a high back; the head must be neither hyper-extended nor flexed, but so placed that it is in the same vertical axis as the spinal column. The person administering the gas should stand on the patient's left side behind the chair, and it will be found most convenient for him to turn on the gas with the left foot.

Care must be taken that there is sufficient gas available at the start to complete the operation. Each cylinder is marked with a gross and net weight, so that the amount of gas contained in each can at any time be readily ascertained. The foot key should be given a turn round before starting, to see if it is working easily, as the tap sometimes get stiff and a spanner is needed to move it.

A little gas should then be allowed to flow through the bag to free it of air, and then it should be filled about two-thirds full. The valves, which, if not used frequently, are apt to become dry and curled up, may be tested by breathing through the face-piece a few times.

The dentist having inserted a mouth prop, the face-piece should be gently but firmly and accurately applied to the patient's face. Leakage of air is very apt to occur at the upper part of the face, at the junction of the frontal and nasal portions of the face. Waving of the fringe in the fair sex indicates this, and it is best arrested by pressing in the sides of the upper part of the face-piece against the nose. The patient should not be told to take long breaths, but simply to breathe as usual—quietly and naturally.

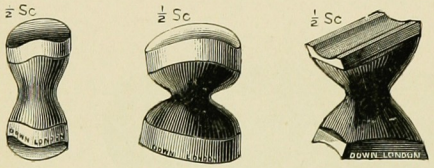


FIG. 7.—MOUTH PROPS.

In the early part of the administration the indicator is kept at "valves," but, after about six to eight breaths, should be turned on to "no valves," and to and fro breathing be allowed. Throughout the administration the bag is kept moderately distended with gas.

The available anæsthesia may be somewhat lengthened by giving a breath of air to every five respirations during the induction of anæsthesia.

Nitrous oxide anæsthesia is divided into three stages, just

like the anæsthesia of chloroform or ether, but the change from one to the other is so rapid that they are not easy to differentiate; neither are they of any great practical importance, beyond the fact that it is necessary to be familiar with the signs and symptoms of the third stage, when the patient is in a condition of true anæsthesia, and the operation may be commenced.

After the first breath or two of gas the patient has a strong inclination to take a deep inspiration, and has a marked feeling of expansion or exhilaration. Consciousness is soon lost, and vivid dreams are common, rendered very unpleasant if the operation is begun too soon.

Signs of Full Anæsthesia.—The patient's breathing becomes deep and stertorous; the complexion is markedly cyanosed, clonic muscular contractions commencing in the orbicularis palpebrarum and extending to the limbs, constituting the phenomenon known as *jactitation*. The pupils are dilated; the conjunctiva insensitive; the pulse full and bounding; the eyeballs rotate from side to side or become fixed, while the features are often considerably distorted and unpleasant to look at.

The average time to induce anæsthesia is	56 seconds.
The average duration of anæsthesia,	39 seconds.

How does Nitrous Oxide act?

Let it be understood at once that, although the appearance of a patient deeply under the influence of nitrous oxide may be highly suggestive of asphyxia, the condition is actually quite different, and nitrous oxide is by no means an asphyxiant.

The late Sir George Johnson actually contended that it merely produced "a beneficial asphyxia"! That it really displaced oxygen from the blood, and when the tissues reached a certain point of cellular asphyxia, they lost their power of receiving and conveying stimuli.

It is hardly necessary to say that an anæsthesia so produced would be fraught with danger, and we know on the contrary that nitrous oxide is by far the safest anæsthetic yet discovered. H. C. Wood, of Philadelphia, declared it to be an asphyxiant. Paul Bert, while recognising that the gas had a specific action on the tissues in producing insensibility, considered that the anæsthesia was yet accompanied by asphyxial phenomena due to air exclusion which he considered essential. Later, he found that anæsthesia could be produced even when air and oxygen were mixed with the gas. Since then the united researches of Dr. Dudley Buxton, Dr. F. W. Hewitt, and Mr. Bellamy Gardner have clearly demonstrated that—

(1.) Nitrous oxide enters into loose combination with hæmoglobin in the red blood corpuscles, and probably is so conveyed to the cells of the nerve centres.

(2.) It exerts a specific effect on the central nervous system.

(3.) The phenomena of nitrous oxide anæsthesia are totally distinct from those occurring in asphyxia.

(4.) The effect of nitrous oxide on the circulation, more especially on the heart, is stimulating, except in so far as the introduction of any gas into the pulmonary circulation, if we exclude oxygen, increases friction, and so interferes in some degree with the circulation.

(5.) A mixture of air and nitrous oxide with a proportion not exceeding 30 per cent. of air, or a mixture of nitrous oxide and oxygen with not more than 12 per cent. of the latter, will produce an agreeable and efficient anæsthesia.

After-Effects of Nitrous Oxide.

The after-effects of nitrous oxide are, as a rule, exceedingly slight and transient; indeed, there is no known anæsthetic which produces less constitutional disturbance.

Slight headache and vertigo, accompanied by a feeling of

lassitude and depression, are occasionally seen. If at all marked, some impurity in the gas may be suspected, or the administration may have been faultily conducted, and too much carbon dioxide administered along with the nitrous oxide from re-breathing, or some blood may have been swallowed. If the patient has had a meal within the last two hours, these symptoms are more prone to occur, and may be accompanied by nausea and even active vomiting.

Accordingly, it is well before administering to inquire when the last meal was taken. Pallor and faintness are due usually to stomachic disturbance and threatened vomiting, rather than to any direct circulatory disturbance.

Two administrations at a sitting can rarely be carried out without causing a good deal of after-discomfort and headache, and should therefore not be undertaken unless the patient lives at a distance, and it is especially desirable to complete the extraction at one sitting.

Ethyl Chloride or Chlorethyl.*

(*Chem. form.* C_2H_5Cl.)

Ethyl chloride has been favourably known for many years as a local anæsthetic, but since 1896, when Carlson discovered that it possessed general anæsthetic properties, it has been steadily growing in favour in this capacity on the Continent, and during the past two years has been very extensively used in our own country, where it has practically displaced nitrous oxide in general surgery.

The drug is a colourless, highly-volatile liquid, with a not unpleasant but rather penetrating odour. It evaporates at all ordinary temperatures without leaving a residue; it is

* Ethyl chloride must not be confused with ethidene dichloride, $C_2H_4Cl_2$, a very different and much less safe anæsthetic agent, never used at the present time.

very combustible, and burns with a green flame, setting free hydrochloric acid. It keeps well, when not unduly exposed to light, and has no tendency to undergo chemical changes and form poisonous by-products. Its density is 0·92 at 0·c.

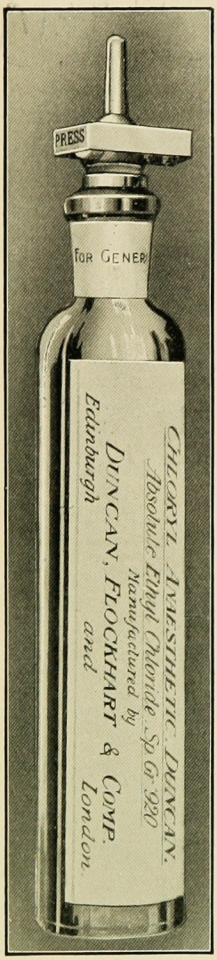


FIG. 8.—AN ETHYL CHLORIDE CYLINDER.

It is put up in flasks containing from 50 to 60 cubic centimetres or about one and a half fluid ounces; these are fitted with patent spring stoppers of various patterns, not all of which are satisfactory.

The Apparatus.—A certain amount of anæsthesia can be induced by simply spraying the drug on to a handkerchief folded into the form of a cone, or on to the inside of a Blake inhaler. If this is done, it is best to measure out 2–3 c.c. for a child, 4–5 c.c. for an adult, into a minim measure and throw it at once on to the inhaler, as freezing is less likely to occur. Such a method answers for emergencies, or where a better inhaler is not available, but for reliable and the best results an inhaler such as we now figure is necessary.

The essential parts for any apparatus which will produce satisfactory and reliable anæsthesia by means of ethyl chloride are, in brief, the following:—

(1.) A one-gallon rubber bag, preferably with a wide mouth.

(2.) A face-piece such as is used for ether or nitrous oxide.

(3.) An angle junction tube for the two.

Such an apparatus can be readily formed from the parts

of a Clover's or Hewitt's inhaler. From the former the inhaler figured below was prepared, the only addition being a simple tube for introducing the ethyl chloride, which passes down the lumen of the vertical arm of the angle junction tube. This modification can be made in the Clover apparatus at a very trifling cost. It is best to avoid the use of any lint or cotton-wool along with this inhaler, as this is quite useless and wasteful of the anæsthetic. There is some little difficulty, and especially for the inexperienced, in measuring the exact amount of ethyl chloride when it is introduced directly from the original cylinder. In view of this, the manufacturers of the drug have placed capsules on the market, containing 3 c.c. and 5 c.c. respectively, and hence there can be no difficulty in administering an exact quantity. The small capsule will be quite enough for a young child, while the larger size, properly administered to an adult, will induce an anæsthesia of from two to three minutes' duration,

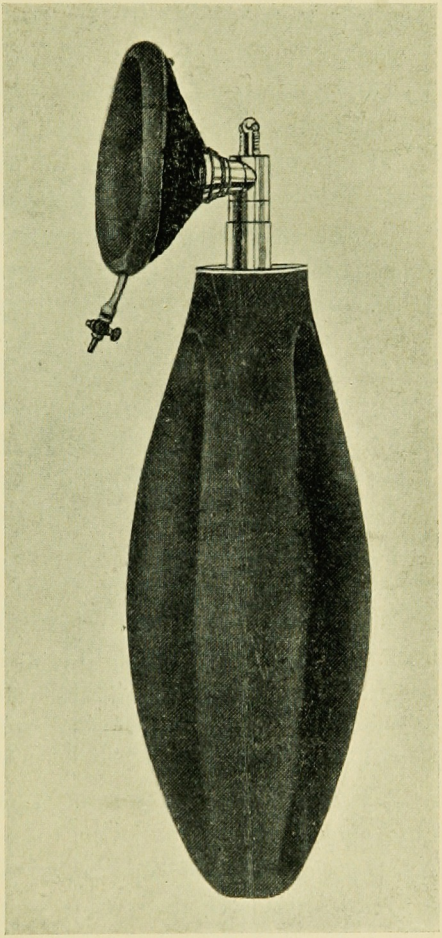


Fig. 9.—Author's ethyl chloride inhaler.

if required. Messrs. Duncan & Flockhart now make a dropping cylinder, whereby the drug may be slowly dropped on to lint or into a bag, and in this manner accuracy in measuring the dose is greatly facilitated. (See Fig. 8.)

The Administration.—Whenever possible, the drug should not be administered until a period of two hours has elapsed since the last meal, as sickness is then less liable to occur. The clothing of the patient should be loosened, the collar or anything tight around the neck being removed.

The patient may be seated in a dental or other chair with perfect safety, but, if more convenient for the performance of the operation, he may be placed on a couch. *If the patient's heart is weak, especially if fatty or myasthenic, the supine position is to be preferred.* After having inquired as to the existence of artificial teeth (which, if present, must be removed), the inhaler—without any anæsthetic in it—is carefully adapted to the patient's face, and he is asked to take two or three breaths to and from it.

After he has been got to breathe freely and comfortably, the ethyl chloride should be introduced. It is best to do this somewhat gradually, as otherwise the vapour in the bag becomes suddenly very pungent, and the patient holds his breath. Although good anæsthesia may be soon obtained, the patient will complain afterwards, in many cases, that "it was very choky."

It is well to take the exact time to a second when the ethyl chloride is introduced into the bag, and it will be found that signs of complete anæsthesia are present before the lapse of ninety seconds in the very large majority of cases; if not, it is more than probable that some air leakage has been going on.

The signs of ANÆSTHESIA are the following:—

Regular, automatic breathing, rapidly deepening to stertor; fixity of the eyeballs; loss of the conjunctival reflex; dilated

pupils; and varying relaxation of the muscular system. The *masseter*, however, is the one muscle which is seldom fully relaxed, and sometimes takes part in the spasm which, during deep anæsthesia, we often notice in the muscles of the extremities. The pulse is full and increased in rapidity, and the face sometimes flushes considerably.

Unless a long anæsthesia is required, it will be best not to push the administration to the production of marked stertor and spasm of the muscles.

The average time required for induction of anæsthesia is 50·9 secs., and the average available anæsthesia 71·3 secs. (M'Cardie); but they both vary, and can be made to vary greatly according to the requirements of each individual case.

The After-Effects of Ethyl Chloride.—Headache and nausea are somewhat common, occurring in about twenty per cent. of the cases, unfortunately, and the frequency of their occurrence is the only thing which prevents this almost ideal anæsthetic from completely displacing nitrous oxide in both dental and general surgery. Untoward effects such as these are far less common after a brief anæsthesia than after a prolonged one where marked stertor with widely dilated pupils has been produced. Further, they seem much less frequent when nitrous oxide is used along with the ethyl chloride. Sickness is less frequent when the patient has been properly prepared, and when the hour of administration is in the morning.

Advantages over Other Anæsthetics.

Over Chloroform:—

(1.) It can be given with the patient in any position.

(2.) Anæsthesia can be induced very much more rapidly than would be possible, or at any rate safe, with chloroform.

(3.) There is no struggling.

(4.) A measured dose can be given.

(5.) It is probably much safer.

(6.) The after-effects are quite trifling or absent altogether.

Over Ether :—

(1.) It is much pleasanter to take.

(2.) Induction of complete anæsthesia is much quicker, and is unattended by struggling.

(3.) There is no cyanosis or secretion of mucus.

(4.) It does not leave an unpleasant taste in the mouth or smell in the room.

(5.) The after-effects are generally much less.

Over Nitrous Oxide :—

(1.) The anæsthesia is of a better type in that it is quieter, there being a complete absence of suffocative symptoms such as opisthotonos and jactitation.

(2.) No cumbrous apparatus is necessary.

(3.) The available anæsthesia is about twice as long.

General Conclusions.

The conclusions arrived at regarding ethyl chloride as a general anæsthetic may be summarised as follows :—

(1.) It is the safest anæsthetic with the exception of nitrous oxide. Owing to its great volatility it is very quickly absorbed, and almost as quickly eliminated.

(2.) It is the best anæsthetic known for what may be called "single dose" cases, when the patient is anæsthetised, the mask removed, and the operation performed without any further administration.

(3.) Children, as a rule, take it very well and quietly—for them it is a perfect anæsthetic for small operations.

(4.) The induction period is often startling in its rapidity if the breathing be deep and free. In over 1000 adenoids and tonsil cases the average period of induction was 51·9 seconds and the average duration of anæsthesia was 64·64 seconds using 2 to 5 c.c.

(5.) Patients with heart, lung and kidney diseases seem to take it very well.

(6.) Recovery from its influence is quite rapid. Vomiting is troublesome occasionally.

(7.) The colour of the patient remains quite natural, cyanotic symptoms being very rarely present.

(8.) There is a marked absence of struggling and noise, and muscular relaxation is as a rule complete at the end of 30 seconds in adults, and generally in half that time in children.

(9.) Of no advantage for larger operations over chloroform or ether, because of the quick return to consciousness.

Ethyl Bromide.

($C_2H_5Br.$)

Ethyl bromide has been used in this country, chiefly by Dr. Brown Kelly of Glasgow, for adenoid operations. It is neither so pleasant an anæsthetic nor as safe as ethyl chloride, but, properly administered, affords a good anæsthesia of one minute or more, and is thus well adapted for a brief operation, such as removing adenoids or tonsils. It has the advantage over ethyl chloride that, with it, no special inhaler is necessary, as it is best given on a towel or napkin held close over the patient's face, all air being practically excluded for the time being. Dr. Brown Kelly gives it on one layer of lint, held close over the patient's face, dropping the anæsthetic gradually.

It is undesirable to repeat the administration at a sitting, as can be readily done with ethyl chloride, and care should be taken to keep the drug * in a carefully stoppered bottle in a cool place. The dose is from $1\frac{1}{2}$ to $3\frac{1}{2}$ drachms, according to the age of the patient.

* Dr. Inglis Clarke says, if properly prepared, ethyl bromide is a very stable drug.

"Somnoforme" is merely a mechanical mixture of ethyl chloride 60 per cent., methyl chloride 35 per cent., and ethyl bromide 5 per cent.; now seldom used.

Signs of Anæsthesia.

In fifty to seventy seconds from the commencement, stertorous breathing ensues. This may be allowed to continue for ten seconds before stopping the inhalation, if a fairly long anæsthesia is wanted. Sometimes the breathing will only become deep and regular, as in profound sleep. The limbs become relaxed, and the corneal reflex is abolished. Voluntary movements cease. If these symptoms do not ensue in less than ninety seconds, and if there are at that period rigidity and iregular breathing, then the drug has been improperly given and too much air admitted.

The face gets somewhat congested or even dusky. Pallor is rare. The eyes often remain open. The conjunctiva becomes congested, and the pupils dilate widely. The pulse may remain normal or become somewhat lowered in tension and irregular, in some cases rapid and increased in tension, as with nitrous oxide.

Muscular System.—Spasmodic contractions and movements of the limbs (jactitation), as under nitrous oxide, are common. Spasm of the masseter is frequently troublesome, and necessitates the insertion of a mouth wedge or Mason's gag before commencing the inhalation.

After-Effects.—Vomiting occurs in about 55 per cent. of cases. This may be merely a transient retching, but is often more severe.

CHAPTER IV

ETHER

(*Syns.—Sulphuric Ether, Anhydrous Ether* $(C_2H_5)_2O$)

Ether was discovered in 1843 by Dr. Crawford W. Long, of Georgia, U.S.A., who used it for anæsthetic purposes, but did not publish any account of his results or draw attention to the discovery. Its introduction as an anæsthetic agent may be safely credited to Morton, a Baltimore dentist, who first used it for anæsthetic purposes on himself in 1846.

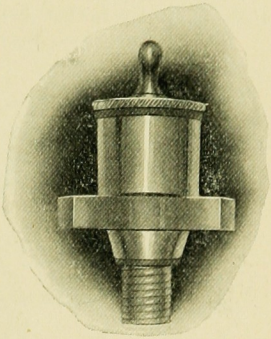


Fig. 10.—Duncan's drop stopcock.

(Exact Size.)

The milled screw-cap adjusts the flow to the degree desired.

Ether is a colourless, very volatile liquid, with a peculiarly strong odour and hot taste; it is highly inflammable, burns with a white flame, boils below 105 F., and contains about 8 per cent. of spirit. It has a specific gravity of ·715 to ·725. The varieties used for anæsthetic purposes are ethylic ether, prepared entirely from ethyl alcohol, and what is called "pure anæsthetic ether," which is carefully prepared from methylated alcohol, from which the wood spirit has been removed. Unless the source is a reliable one, however, and this is quite certain, it is better to employ ethylic ether. Crude methylated ether, such as is used for disinfecting and cleansing the skin prior to an operation, is inadmissible as an inhalant.

The Administration.

Three methods of ether administration are commonly employed at the present day:—

(1.) The Open Method.

(2.) The Semi-open Method.

(3.) The Close Method.

(1.) **The Open Method** has always been in favour in America, and just lately has been rapidly coming into popularity once more in this country.

It will be well, therefore, to devote some little attention to the method. A mask of the Schimmelbusch type may be used carefully covered with six to ten layers of surgical gauze. As the mask must fit the face perfectly, and all air breathed by the patient pass through the ether-impregnated gauze, it is necessary to make a little face-pad of gauze or cotton-wool, about the thickness of one's ring finger, which is laid on the face to act as a cushion for the metal rim of the mask (see Fig. 11). It is loosely laid upon the face, forming an oval which covers the closed eyelids and encircles the mouth and nose.

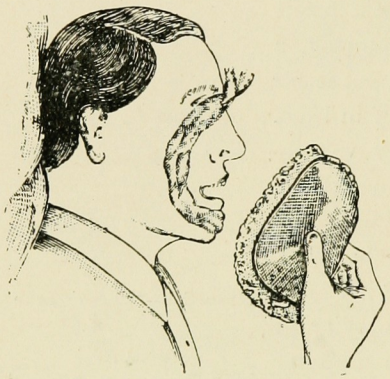


Fig. 11.

The dry ether mask is then superimposed, and the patient, who of course is in the supine position, is directed to breathe regularly and slowly through the mouth.

Ether is then dropped steadily on to the gauze, so as to keep it moist but not saturated. Some degree of conversation should be kept up with the patient, and he should be quietly coaxed into an unconscious condition. The smell of the ether, so given, is not usually complained of, as it is not in great concentration, and in temperate people struggling is rare. An extremely useful and ingenious mask, giving most satisfactory results, is one recently introduced by Dr. Ferguson, of Boston. It is a little more complicated in arrangement, but well repays the little attention to detail needed. It is in two parts, made

of small flexible copper wire, and is fitted up for use as follows:—

Remove the flexible retaining wire, E, (Fig. 12) and then fit the wire frame, A, B, C, E, accurately to the face of the patient. As the face wire, B, and the convex portion, A, are made of very flexible wire, the fitting can be easily done by bending the wire between the fingers. After the frame has been thus fitted, place over the convex portion, A, several layers of surgical gauze of such size as to completely cover the convex portion, A, and which, when pressed in place and held taut by the flexible wire, E, as in Fig. 13, will allow a margin of gauze around the inhaler of one-half or three-quarters of an inch in width. Then insert the flexible retaining wire, E, and press it home, thereby stretching and retaining the gauze.

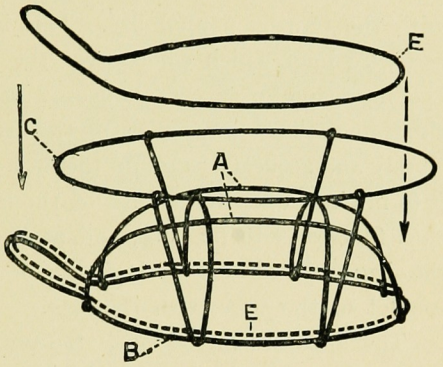


Fig. 12.

The number of layers of gauze to be used is dependent upon the size of the mesh of the gauze. As much gauze should be used as can be employed without in any way embarrassing the respiration of the patient. To determine this, the anæsthetist should lay several thicknesses of gauze over his own face, while in the supine position, and add layer after layer until he finds that

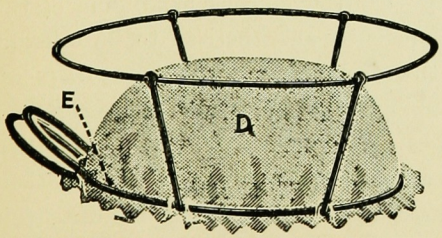


Fig. 13.

his respiration is somewhat impeded; then several layers should be removed. Of course this procedure need not be followed for every operation, for if the same kind of gauze is customarily used the number of layers can be determined once for all. Usually, six to ten layers suffice.

After the gauze has been adjusted, cover the whole frame with the Canton flannel bag. This is done by first inserting the wire loop, which comes over the nose, through the small opening made for it, and then drawing the rest of the bag over the frame. The lower part of the bag should be made to fit closely and accurately around the face wire, B, without allowing it to impinge upon the mouth of the inhaler. The inhaler will thus fit closely to the face, and, at the same time, the edge of the bag will form a cushion which will prevent any harsh contact of the wire with the face.

The apparatus, now ready for use, is laid gently over the face of the patient. *If properly fitted, no air will pass between the face of the patient and the inhaler*, but all air will go in and out through the opening, G (Figs. 14 and 15). Allow the patient to breathe through the inhaler, in order that he may feel that his respiration is not embarrassed, then allow a drop of ether to fall through the opening, G, on to the gauze, D; in two or three seconds allow another drop to fall, and repeat this process several times.

Soon it will be found that the mucous membrane of the respiratory passages is sufficiently anæsthetised to be tolerant of the ether, and then the dropping may be more frequent. The rapidity of the dropping must be learned by experience. Usually, after the passages have become tolerant of the ether, about two or three drops a second will suffice to put the patient in a state of surgical anæsthesia in about five minutes, this being accomplished without any manifestation of the so-called secondary stage, except, possibly, a fixation of the chest. If this occurs, it is not an alarming symptom, and the inhaler should not be removed but kept upon the face and the ether continued.

Soon the respiration will begin again, or it may be hastened by gently compressing the chest or abdomen.

To maintain the surgical anæsthesia thus produced, the dropping should be continued; as the anæsthesia proceeds and deepens, the dropping may be less frequent. The amount of ether necessary can be determined by an intelligent watching of the operation. This the anæsthetist does in order that he may conduct a better anæsthesia. By thus watching the operation and noting whether the reflexes remain abolished, the ether may be so regulated as just to maintain surgical anæsthesia, from which the patient will revive very quickly as soon as the inhaler is removed from the face.

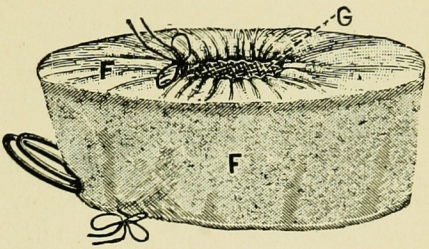


Fig. 14.

The advantages of maintaining such an anæsthetic state are clearly manifest, namely: so-called ether-shock is reduced to a minimum, for it results not so much from the length of time the patient is under the ether as from the amount of ether that he absorbs; and, again, not only is recovery more speedy, but it often takes place without vomiting and little nausea, always provided, however, that *pure* ether be used. A patient, especially in operations about the mouth or nose, may vomit mucus and blood which have been swallowed, but nothing more. Of course these statements refer to cases that have been properly prepared for the operation.

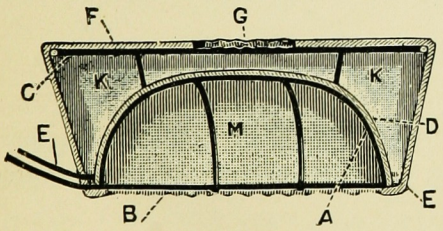


Fig. 15.

Alcoholics and those addicted to the opium habit take ether badly, but with them excellent results have been obtained with this instrument.

The Canton flannel bag with the hole in the top is intended for an operation in the supine position. For adenoid, mastoid and similar operations, in which it is necessary to keep the patient's head on one side, a cover closed on top and having the opening in the side should be employed. Such covers, one for the right lateral and one for the left lateral position, are supplied with this inhaler.

After the operation the Canton flannel bag should be put in the wash, the gauze thrown away, and the wire frame dipped in some non-corrosive antiseptic solution. For the next operation fresh gauze and a clean bag should be used.

By means of this inhaler surgical anæsthesia may be induced in from three to five minutes with half an ounce of ether, and for an operation lasting close on two hours anæsthesia has been kept up with four ounces of ether, and on the average it does not take much more than this. Of course when the patient is alcoholic things are different, and it is very often necessary to use some morphia, or morphia and scopolamine, to aid the ether in subduing sensibility—1/6 to 1/4 grain of morphia and 1/200 grain of scopolamine being a usual amount.

The remarkable difference in the type of anæsthesia compared with that of the closed bag inhaler is very striking.

In the first place much less mucus is secreted, and there seems to be much less tendency to coughing and laboured breathing.

The respirations are more uniform, less deep, and there is no heaving of the abdomen so often complained of when ether is administered by a closed inhaler. The colour of the face is more of a healthy pink, and there is an absence of cyanosis.

Bleeding from the wound, usually very free with the closed

method, is much less marked. The muscles become completely relaxed, and there is a singular freedom from reflex laryngeal spasm and disturbance of the respiration due to stimuli in the area of operation.

The possibility of completely sterilising the whole inhaler and gauze is in these days a notable advantage.

It is found, as experience increases, much less ether is used than at first. At the beginning of any operation the anæsthesia requires to be much deeper than later, generally speaking, when a much lighter degree may suffice.

Of after effects, with this method, sickness and bronchitis are the chief, but sickness is much less common than when the closed method is used, and bronchitis no more frequent.

(2.) **The Semi-open Method.**—The apparatus most commonly used for this purpose are the following:—

1. Blake's Inhaler (somewhat modified by the author).
2. Rendle's Mask (only those made of celluloid or metal, as suggested by Silk, are admissible).

Of these the modified Blake inhaler is, all things considered, the best and most generally useful, and is largely employed in America. It consists of a truncated pyriform cone, of tin-plate or German silver, about 7 ins. long; the upper aperture is about 2 ins. × 1 in., and the lower about 4 ins. × 3 ins. This may be fitted with a pneumatic rubber face-pad, so that, when used for administering ether, the air supply can be controlled; but, on the other hand, if the inhaler is being used for CE, this pad is not employed, and more free air supply must be allowed. Inside this larger cone is placed a smaller complete cone of stiff wire-gauze, rendered more rigid by a circular metal band at the base; on to this cone, before inserting it, is wound some narrow domette bandage, only as much being put on as will leave the apex of the cone uncovered. This domette bandage acts as the vehicle for the ether (just as the sponge does in Silk's cone). The inhaler is really very

much like an Ormsby without the bag, and, when using it for an average type of patient, very little more ether is necessary than is used with an Ormsby, or even a Clover, to keep up a satisfactory degree of anæsthesia, seven to eight ounces an hour being usually necessary. One great advantage of this apparatus is that it can be completely sterilised—by boiling if necessary—before and after using it; and the face-piece can be soaked in 1-20 carbolic lotion. Silk's metal inhaler can be treated in the same way, but Rendle's (celluloid) of course cannot be; the leather Rendle and "Hyderabad cone" are simply germ carriers, which it is next to impossible to satisfactorily disinfect.

Technique of Semi-open Etherisation.—The administration of ether by the semi-open method is extremely simple.

If the anæsthesia is to be conducted with ether alone, a drachm or two should be placed within the inhaler, and the latter held at such a distance from the patient's face as to avoid coughing and holding of the breath, and then gradually approximated as the patient gets accustomed to the vapour. If too strong a vapour is employed, spasm of the larynx and a sense of choking are produced, which may become unbearable; while if the ether is applied too sparingly, the induction of the anæsthesia will be unduly protracted, and the patient may get excited and troublesome. It is of great importance to gain the confidence of the patient, and get him to realise that, disagreeable as the proceeding is, it is for his good; and, while beginning with a dilute vapour, to gradually and progressively increase the strength as soon as the patient gets dazed and is losing consciousness.

The respiratory rhythm is always more or less interfered with by swallowing movements and temporary closure of the larynx, but by degrees the larynx gets accustomed to the vapour, its reflex is subdued, and the breathing grows regular.

(3.) **The Close Method.** — Until quite recently either Clover's or Ormsby's inhalers were almost exclusively used for administering ether by this method, but a few years ago Dr. Hewitt brought out his improved wide-bore Clover inhaler, which is the best apparatus of the kind obtainable.

With no other are there the same ease and comfort in the production of anæsthesia, both as regards the anæsthetist and the patient, which are experienced with what we shall in future refer to as Hewitt's inhaler.

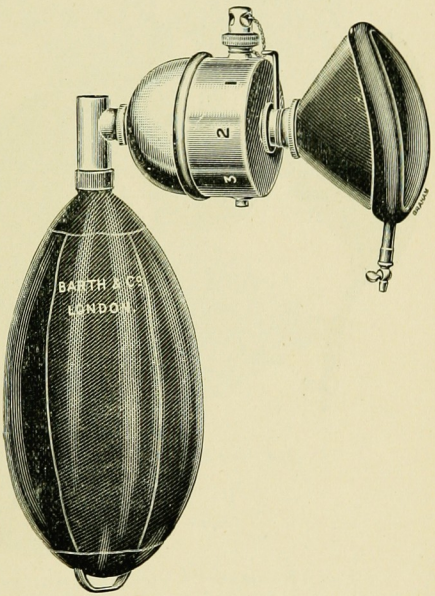


Fig. 16.—Clover's inhaler.

It is in several ways superior to the ordinary Clover, and costs very little more. It is scarcely possible too strongly to condemn the cheap type of Clover inhalers, as a rule "made in Germany," and sold in a flimsy leatherette case for about half the price of a good apparatus. They are, as a rule, very badly constructed, and only calculated to make the inexperienced think that the administration of ether is an extremely difficult and tedious matter. As will be seen from the diagram, Hewitt's inhaler is somewhat different in shape from the ordinary Clover; it is not fitted with a circular water-jacket, but has a small tank or thermophre on one side which answers the same purpose. There is a much larger opening than in a Clover for introducing the

ether, which can be effected without removing the inhaler from the patient's face, and instead of the chamber revolving on the shaft, this latter is revolved within the chamber by means of a handle fixed to it. The face-piece is an exceedingly well-made one, and is attached to the ether reservoir by screwing it on to a thread. There is thus no risk of the face-piece becoming detached when a patient struggles violently, as sometimes occurs with a Clover. But the most important improvement, undoubtedly, is the wider bore of the shaft, which enables the patient to breathe with greater ease and freedom, doing away with much of the somewhat suffocating sensation which may be experienced with a Clover, and hastening the induction of anæsthesia.

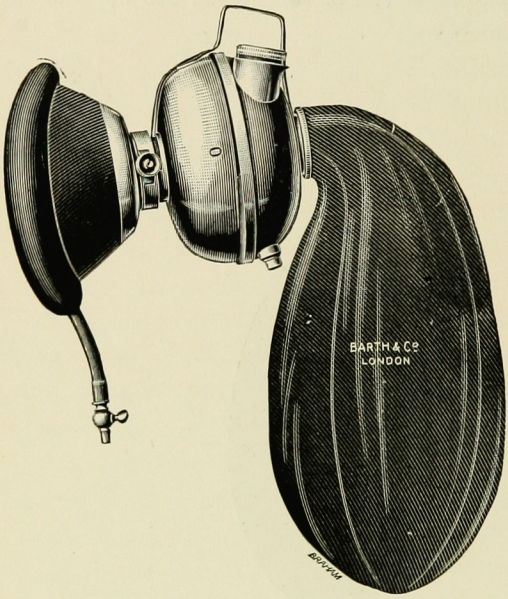


Fig. 17.—HEWITT'S WIDE-BORE INHALER.

When the index stands at O, the slots in the shaft and the casement of the shaft are in diametrically opposite positions, and no ether can pass out of the reservoir; at 1 they partially overlap, at 2 they do so to a further degree, while at F or full, as shown in Fig. 20 *B*, they completely coincide, and ether is passing freely from the chamber into the shaft and thence into the bag and the patient's lungs.

A great deal of importance must be attached to the construction of a face-piece, which should be so designed as to adapt itself closely around the patient's face, and not allow

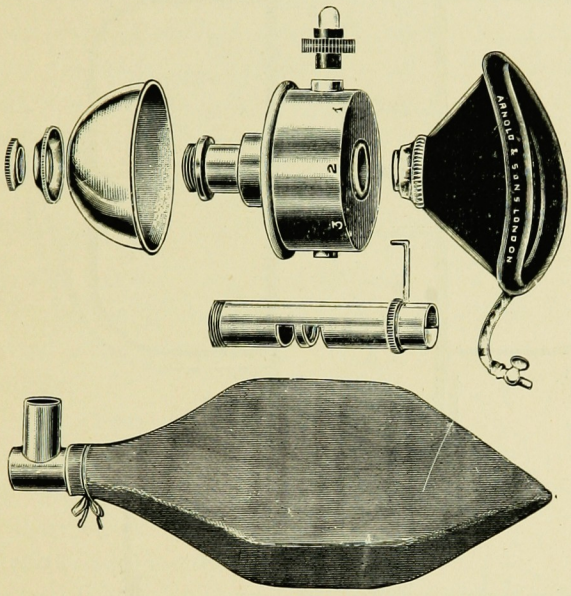


Fig. 18.—clover's inhaler in separate pieces.

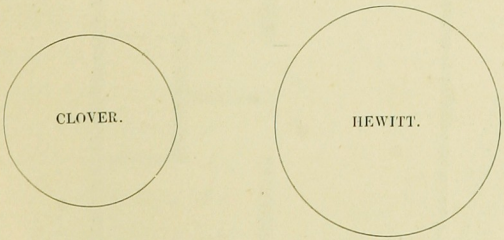
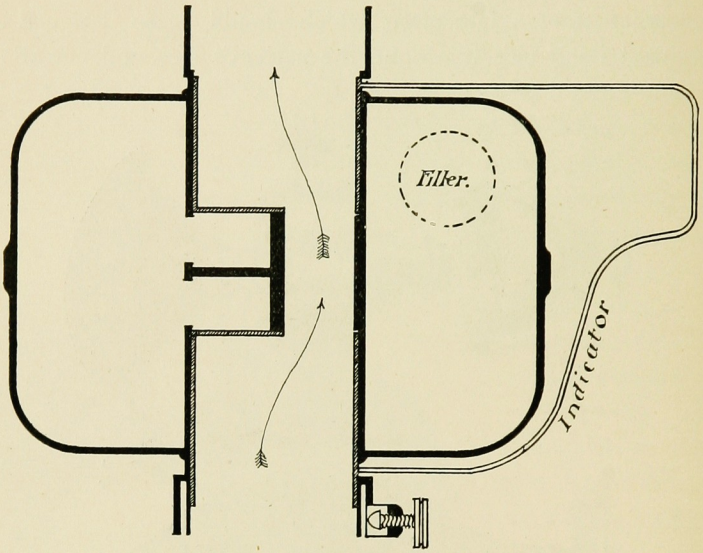
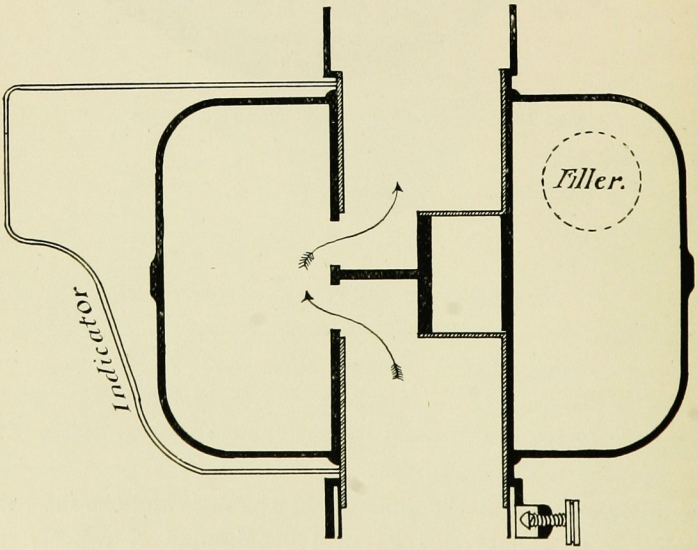


Fig. 19.—comparative size of the bores.

any leakage of air at the junction of the nose and the internal canthus. It should not be oval or circular as regards its shape on cross section, but narrow at the top and broad at



A.—INDICATOR AT O.



B.—INDICATOR AT F. (FULL ETHER).

FIG. 20.—CROSS SECTIONS OF THE CHAMBER OF HEWITT'S INHALER.

the base; looked at from the side the cushion should form an arc of a large circle and not be simply vertical.

The accompanying diagrams will show the features of a good type of face-piece better than they can be described.

Rubber and leather face-pieces (the leather being used for foundation) are always to be preferred to celluloid face-pieces.

Messrs. Barth & Co. make an excellent face-piece of solid vulcanised rubber, which is most durable.

Rules for using Clover's or Hewitt's Inhaler.

I. If the inhaler has recently been used for another operation, thoroughly cleanse the face-piece with 1 to 20 carbolic and warm water and dry carefully.

II. Pour out any ether left in the chamber from the previous administration.

III. Pour an ounce and a half of ether into the filling tube, replace the stopper, and see that the index points to O.

IV. Adjust your face-piece to the shaft, and blow through the apparatus to remove any traces of ether vapour present in the shaft of the apparatus.

V. Carefully adapt the face-piece to the patient's face, ask him to blow out, give him a breath of air, get him to expire again, and repeat this until your bag is three-fourths full, but on no account blow up the bag with your own expirations.

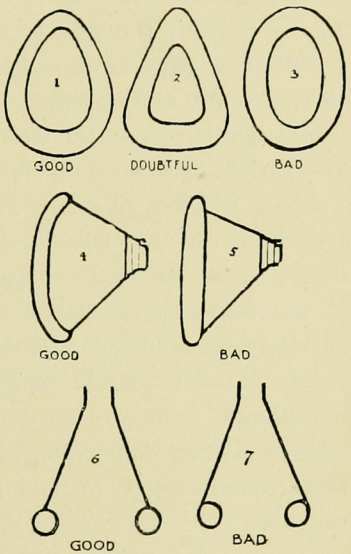


Fig. 21.—face-pieces.

VI. Having allowed the patient to breathe backwards and

forwards two or three times, carefully turn the indicator on about an eighth of an inch. The patient's face should be now turned on its side, so that any saliva which is secreted lies on that side and may later be removed with a towel. This is *most* important. Now turn on your indicator another eighth of an inch, and, if the patient does not hold his breath, increase this. If the ether be turned on too quickly, the patient will hold his breath and cough and retch; and sneezing is sometimes seen. If the patient does hold his breath, turn back the reservoir till his breathing is again regular. The respiratory rhythm is nearly always interfered with to a slight extent by swallowing or temporary holding of the breath; but, after about a minute and a half, the breathing becomes regular and deeper — probably simultaneously with the loss of consciousness. The administrator should now turn on the ether more freely than before, but not so rapidly as to excite the heart; not in jerks, but slowly and progressively. No fresh air having yet been admitted, the patient will probably look rather dusky.

VII. Do not give any fresh air until there is a distinct indication for it. Disregard moderate duskiness or lividity unless associated with impaired respiration or circulation; if the breathing is stertorous along with lividity, air must certainly be admitted. Healthy, vigorous patients more commonly become quickly dusky than patients in a condition of asthenia from prolonged illness. If the air be too early admitted when the patient is dusky, he will very probably come round enough to hold his breath, set his teeth, or start coughing, and give the administrator trouble. When the patient is once thoroughly under, generally from three to four minutes from the commencement, an inspiration of air may be allowed, the administrator taking care to catch the next expiration in the bag. The more vigorous the patient, the more necessary is it to be careful as to the amount of air admitted, if anæsthesia is to be secured without struggling or

excitement. When dealing with feeble patients and those who are gravely ill, speed in securing anæsthesia must yield to regard for the patient's colour.

VIII. Roughly speaking, a breath of air may be given in every five inspirations, but the more air the patient gets the more ether he will require to keep him anæsthetised. I have latterly found that it is quite possible, once having got the patient well anæsthetised, to keep him so when the bag is removed and ether turned to full, re-application of the bag being only necessary if the patient shows signs of lightening anæsthesia.

IX. If the patient shows symptoms of excitement and commences struggling, the inhaler must be closely applied and ether pushed. The asphyxial element, which is so dangerous under chloroform at any stage, is without any considerable risk when we are giving ether; the only point being that the more air deprivation the patient is subjected to during the operation, the more likely he will be to suffer from severe after-sickness and headache. In persons with feeble circulation and elderly people with possibly atheromatous arteries, the administrator should avoid any prolonged suspension of breathing, and not run any risk of putting too great a strain on the disordered circulatory apparatus.

X. In dealing with children and women not of a robust type, it will be often sufficient to keep the index at some point between one and three; but, on the other hand, with strongly built alcoholic males, it will often require the closest application of the inhaler to keep the patient relaxed and passive.

XI. Generally speaking, the initial ounce and a half of ether will last fifteen minutes, but in patients of stalwart build, in robust health, it will be well to add another ounce prior to the commencement of the operation.

XII. In cold weather, warm the chamber of the inhaler before a fire for five or six minutes, or immerse it in *hot* water.

If the cone inhaler be used, the metal part may be similarly warmed, while, instead of a bandage, a hollow cone sponge carefully wrung out of hot water by twisting it in a towel may be used. This causes the ether to evaporate more readily.

These details, trifling as they may seem, will often make all the difference between good and bad anæsthesia.

Ether is now so generally taking the place of chloroform for the routine production of anæsthesia that the phenomena attending its inhalation are worthy of careful consideration and study. To administer successfully, some amount of training is essential. With proper attention to a few guiding principles, and with a little practice, the administrator will find he is able to materially lessen any disadvantages ether may have as an anæsthetic, and, without danger to his patient or anxiety to himself, produce by its means a most satisfactory anæsthesia for surgical operations. Ether anæsthesia is as safe as profound surgical anæsthesia can reasonably be expected to be, although there is an amount of respiratory activity frequently caused, not seen in chloroform, and although the air-passages are more often temporarily occluded than when that anæsthetic is employed. The most important point concerning the use of this valuable agent is that, when once a deep narcosis has been produced, the administrator may feel assured that he will receive sufficient warning, should untimely symptoms occur, to meet them with deliberation and success. When chloroform is being used, patients not infrequently pass into a condition of some danger with little or no warning to the administrator. Under ether, healthy patients may be raised into a sitting posture; may be subjected to a slight operation before they are very deeply anæsthetised; their air supply may be so restricted that considerable cyanosis is occasioned; and yet the circulation will not show that liability to sudden fluctuations and depressions so commonly seen under chloroform. Moreover,

the breathing under ether is usually quite obvious and audible, and any alteration in rhythm or character may be at once noticed; the inaudible and sometimes shallow respiration met with under chloroform is almost unknown under ether.

Owing to the rapidity with which patients become anæsthetised by ether, under ordinary circumstances, with a closed inhaler like Clover's, we do not now have such an opportunity of studying the so-called stages of the inhalation. They do not differ to any marked extent from those of chloroform anæsthesia.

First Stage.—Swallowing, cough, and some holding of the breath are rather more common than with chloroform, except when the administration of the ether is preceded by nitrous oxide. The pulse is considerably accelerated, and the pupils are large and very mobile. The patient rapidly gets into a state of analgesia, in which, though perhaps conscious to some extent of his surroundings, he will not experience pain from the infliction of an injury.* A tooth, for example, may be painlessly extracted during this stage, the patient being aware, however, that something is being done, and even talking very distinctly. Simple incisions may be made, sutures and drainage tube may be removed, and various other brief operations and manipulations carried out without suffering to the patient.

If the ether be pushed no further than the height of this stage, the patient is in his usual condition in about ten minutes, and will probably suffer from no after-sickness, but may go about his business as if nothing had been done.

Second Stage.—The patient becomes abruptly unconscious; memory, volition, and intelligence are abolished; questions may be answered, but the answers will be nonsensical.

* Known in the United States as "Primary Anæsthesia," and largely utilised for minor surgical operations.

Struggling, shouting, and singing may be met with in robust patients. If the patient struggles, his movements must be just passively resisted. He must have no sense of antagonism, and strapping to the table or mechanical restraint of any kind is most undesirable. During this stage we sometimes see the phenomenon known as "Ether tremor." In the author's experience it has occurred in somewhat less than two per cent. of cases. It is speedily put an end to by deepening the anæsthesia. The patient's face is flushed, his conjunctiva injected, and perspiration, especially over the face, is commonly seen. The pulse remains quickened and robust in quality. The breathing is inclined to be somewhat hampered during this stage, owing to a tendency to general muscular spasm. As the anæsthesia deepens, however, the breathing becomes regular, and commencing stertor may be detected.

With a close inhaler the first two stages are passed over, and the third stage of deep anæsthesia reached, in three to four minutes.

Third Stage.—In this stage we have the typical signs of true surgical anæsthesia. The cornea is insensitive to touch. Muscular relaxation is present, and the extremities are flaccid. The breathing becomes regular and somewhat stertorous; the stertor, along with the duskiness which will often accompany it, is speedily relieved by allowing some breaths of air.

The operator, if unaccustomed to ether, not uncommonly remarks on the blueness of the patient's blood on making his incision, but this is speedily eliminated by a few breaths of air.

The pupils differ from chloroform pupils in some respects. Their size varies from $3\frac{1}{2}$ to $4\frac{1}{2}$ mm., and they sluggishly respond to light. No great reliance can be placed on the pupils as land marks until the anæsthesia has been established for a little time. The administrator need not be

alarmed by an extremely dilated pupil if the patient's colour be good, for, in certain cases, it is impossible to obtain a very deep anæsthesia without this.

The pulse is full, bounding, and regular; and incised parts are often very vascular, the surgeon not uncommonly remarking on the free hæmorrhage. The pulse has somewhat slowed down from the earlier stages. Some patients perspire very profusely.

Difficulties and Complications during Ether Anæsthesia.

During the administration of ether, complications and fatalities occur much in the same manner as with chloroform, but we find the possibilities and occurrence of fatalities are much less numerous.

The complications which we most frequently have to encounter are the following:—

(1.) Overdose—by pushing the anæsthetic too far. The respiration will show signs of commencing failure; the conjunctiva will be insensitive to touch; the pupil more or less dilated; the colour dusky rather than pale; the eyelids slightly separated, but the pulse often remarkably good considering the respiratory depression. However failure of respiration may arise, *the circulation of the patient at the moment when breathing ceases is sufficiently satisfactory for remedial measures to be almost invariably successful.* In other words, when the breathing ceases from excess of ether in a healthy patient, the pulse is still beating at the wrist. Simultaneous cessation of breathing and pulse, occurring sometimes from too rapid administration of a large quantity of chloroform, is unknown with ether anæsthesia in moderately healthy persons.

(2.) Respiratory embarrassment leading to failure may occur independently of an overdose, especially during early anæsthesia, often passing away as soon as the anæsthesia is deep. It may be due to masseteric spasm, swelling of the tongue, and a varying degree of laryngeal spasm. Florid, vigorous subjects may clench their teeth and hold their breath, necessitating the insertion of a mouth wedge or Mason's gag. Respiratory embarrassment from these causes, unless it has existed for a considerable period, is always unattended by cardiac depression.

(3.) Failure of circulation independent of overdose is practically unknown apart from some pre-existing condition of a pathological nature, such as goitre, grave cardiac disease, the occurrence of profuse hæmorrhage, or severe surgical shock.

(4.) Foreign bodies, blood and vomitus, may pass into the larynx and trachea, just as in chloroform.

(5.) Apoplexy has been recorded, but is extremely rare. The administrator should take this possibility into account, however, in dealing with a patient of advanced years with brittle atheromatous arteries.

The rules guiding the administrator as to the depth of anæsthesia in ether differ a little from those in chloroform. The proper level of anæsthesia will vary entirely according to the nature of the operation. Abdominal sections, operations on the genito-urinary tract, or in the region of the rectum, especially where dilatation of the sphincter is requisite, call for profound anæsthesia. Some patients seem to have peculiarly irritable vomiting centres, and in dealing with these, particularly during operations on the abdomen and the region of the neck, deeper anæsthesia will be necessary to completely paralyse this centre. The administrator is, as in the case of chloroform, guided by—

(1.) The respiration.
(2.) The occurrence of swallowing movements.
(3.) The lid reflex.
(4.) The size of the pupils, and their mobility or fixity as the case may be.

Contra-Indications to Ether.

Ether is best avoided in the following conditions:—

(1.) In protracted operations about the jaws and mouth (other than the extraction of teeth), the nose, pharynx, &c., which necessitate the mouth and nose being uncovered.

(2.) In all operations necessitating the use of the actual or thermo cautery, or naked lights in the immediate vicinity of the mouth. In such cases the risk of explosion from the inflammable nature of ether overshadows all its advantages.

(3.) For patients who are suffering from active bronchitis, simple or tubercular, and those who are subject to "winter cough." In the markedly emphysematous asthmatical.

(4.) For the subjects of renal disease, in whom the ether may add to the congestion of the kidney, and induce suppression of urine. If ether be used at all for such cases, it must be given with great caution, and sparingly.

(5.) For the subjects of brittle atheromatous arteries, and patients who have aneurism of the thoracic or abdominal aorta particularly.

(6.) For all patients suffering from pathological conditions which cause narrowing (from pressure, &c.) of the respiratory tract, such as simple or exophthalmic goitre, cellulitis of the neck, and diphtheria.

(7.) In empyema, as a rule, pleurisy with extensive effusion, or very extensive ascites.

(8.) For patients who have large tonsils or adenoids (if the anæsthetic be given for an operation of some length and not simply for their removal).

(9.) In operations on the brain, in which, as a rule, it is desired to have the area of the wound as free from blood as possible.

(10.) In all cases, of whatever nature, if the secretion of saliva and mucus becomes excessive and leads to respiratory obstruction and cyanosis, or if the breathing of the patient becomes tumultuous and embarrassing to the surgeon.

CHAPTER V

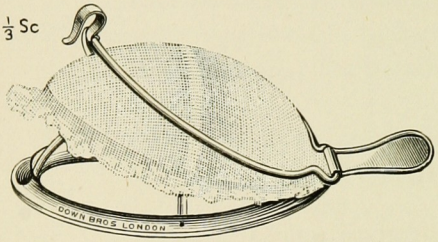
CHLOROFORM ($CHCl_3$)

CHLOROFORM is undoubtedly the anæsthetic we could least do without. Discovered in 1831 by James Guthrie, of Sackett's Harbour, New York, and by Soubeiran, quite separately, neither of them being aware of its therapeutic value and anæsthetic power, its chemical formula was ascertained by Dumas in 1835, and Simpson first drew attention to its anæsthetic properties and used it for pain-killing purposes in 1847. It is a colourless, transparent, mobile, volatile liquid, with a sweetish not unpleasant odour and fiery taste. Only that made by a thoroughly reliable firm should be used. There are three well-known Edinburgh makers, whose names it is needless to mention, and in these the fullest confidence can be placed. It is an interesting fact that most of the chloroform used all over the world is made in the city where it was first employed.

Chloroform will keep well if stored in a cool, dark cupboard in small bottles. Some chloroform made during the Russian War, with two per cent. added alcohol, by MacFarlan, has kept in good condition since 1857. If, owing to circumstances, chloroform has been laid aside for some time, it should be carefully examined before using.

(1.) It should have a S.G. of 1·495 at 62° F.
(2.) It should be transparent and colourless.
(3.) It should be neutral to test paper.
(4.) It should have an agreeable non-irritating odour.

The Apparatus for Administering.—The vehicles most commonly employed are the following:—



A Handkerchief.
A Napkin.
A Piece of Lint.
Schimmelbusch's Mask.
A Towel.

FIG. 22.—SCHIMMELBUSCH'S MASK.

These must be supplemented by some form of drop bottle, of which there are various patterns — Skinner's and Mill's being the best. A quite efficient but inexpensive drop bottle can be readily improvised with a flat 2-oz. medicine bottle and a perfume stopper.

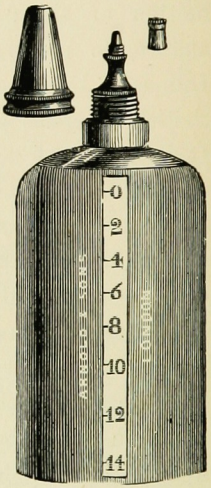


FIG. 23.—SKINNER'S BOTTLE.

Technique of the Administration.—The patient, having been as carefully prepared as circumstances permit, is laid in the supine position,* and, whenever possible, on the table on which he is to be during the operation. Nervous patients may object to this, and then the anæsthetist must accommodate himself to circumstances. It is very objectionable to have to give chloroform to a patient lying in bed, but if it has to be done, the patient should be asked to lie, so far as possible, diagonally across the bed.

* Chloroform, more than any other known agent, rapidly abolishes the vascular mechanism which compensates for the hydrostatic effect of gravity (L. Hill).

The physiological experiment of glass tube and rubber tube and stop-cock, connected with a water-cistern, very well illustrates the difference between the blood-vessels under the influence of chloroform and normally. In a patient fully under chloroform the arteries have almost as little capacity to compensate for gravity as a gas-pipe.

If two or more pillows are desired, the anæsthetist may concede the point to humour the patient, as many as necessary being removed when unconsciousness has supervened.

It gives no offence in these days, even with the fair sex, to inquire as to the presence of artificial teeth; if they are present, they should, of course, be removed. A few words are necessary to reassure the patient, and gain his confidence, as he is almost certain to be dreading the anæsthetic more than anything else. "They are told they will know nothing of the surgeon's work, but they do know that they will be unpleasantly conscious of those palpitating sensations which precede the anæsthetic sleep. To lie on a table and breathe a subtle vapour which will soon cloud the anxious brain and plunge the throbbing personality into an outer and uncertain darkness, is no slight ordeal" (Treves).

The attitude of the anæsthetist must therefore be one of kindly sympathy, blended with sobriety, and he should endeavour to inspire the patient with confidence in his carefulness and experience.

Turning the patient's head slightly to one side, a few drops of chloroform are sprinkled on to the centre of the mask or lint, which is gradually brought to within about half an inch of the patient's face. No coughing or choking should be produced, but as soon as the patient has become accustomed to the vapour, the mask should be removed, and about half a drachm of chloroform sprinkled on the inside layer of lint, and the mask again approximated to the face. This should be repeated about every thirty seconds until the patient loses consciousness, in a normal case. On no account must any air restriction be permitted, but an interval of about half an inch should be allowed to remain throughout the administration between the patient's face and the margin of the mask. If struggling occur, the chloroform should at once be withdrawn, and the struggling be passively resisted, any violent movements being restrained. When the patient quiets down again, as he

invariably will if rationally treated, the administration may be resumed.

Care is necessary to see that the lint on the mask does not become so saturated with chloroform as to allow of dripping on to the patient's face. If this be seen to, and the patient's face kept on the side throughout the administration, the use of vaseline, to prevent blistering, will be superfluous.

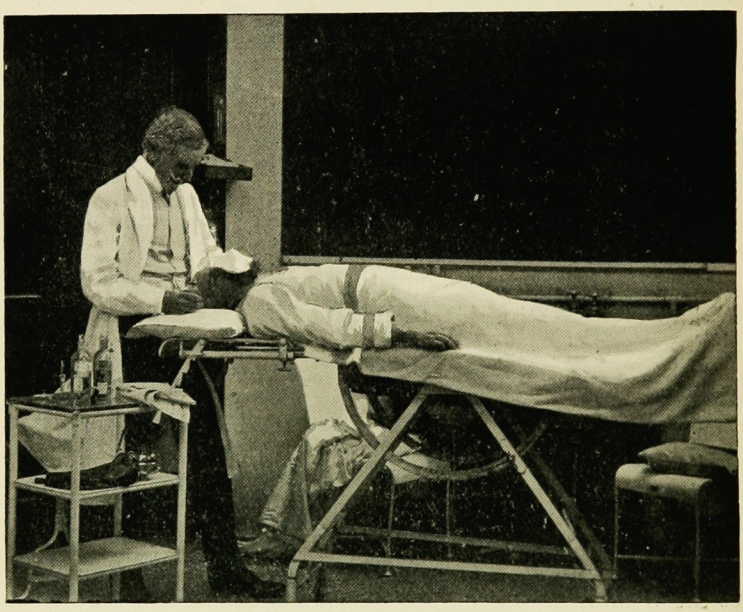


FIG. 24.—ADMINISTERING CHLOROFORM ON A SCHIMMELBUSCH MASK.
(The head should be a little more on one side.)

From the time of the introduction of chloroform until quite recently, the Edinburgh method has been to use a towel, in one form or another. Syme's method was to fold it into a sort of cone, open at both ends, and fastened with a safety-pin. Simpson gave chloroform on a single layer of towel spread over his fingers, whilst Lister used the corner of a towel drawn through a safety-pin. Others have recommended the folding of the towel flat in several layers—about

6 ins. by 10 ins.—and then bending the oblong thus produced to the shape of a ridge tile. The chloroform has generally been poured on freely from the original ½-lb. or 1-lb. bottle, and no particular regard paid to the quantity used. While this has—or should have—the advantage of making the administrator watch his patient and not count the drops of chloroform, it undoubtedly puts the patient in a position of unnecessary jeopardy. Too large a quantity is put within his reach at one time, and if the administrator's attention is distracted for a moment or two—no uncommon occurrence with the beginner—an overdose may be inhaled. While a fatal issue need not always result, yet "scares" and need for restorative measures are more common than if the anæsthetic be added in a somewhat more homœopathic manner.

Chloroform should, if possible, not be administered in a room in which a gas stove or paraffin stove is used for heating purposes. If it be, a very irritating body, phosgene gas, is formed, which may induce fainting, collapse, and even fatal pneumonia in the operators or patient.

The essential principle in chloroform anæsthesia is merely to give sufficient to get the patient completely anæsthetised, and then by repeated small doses—the call for which is seen by the closest observation of the patient—to keep up a degree of anæsthesia suitable for the operation being performed. This is what may be termed the "continuous" method. To merely get a patient anæsthetised, and then wait until obvious and active signs of returning consciousness, such as vomiting and struggling, show themselves, is an elementary performance in no way adapted to the successful carrying out of modern surgical operations.

Chloroform cannot be used "to charge up a patient" in the manner in which ether is employed occasionally, for it is far too powerful a poison. Ringer has shown that it is ten times as powerful an anæsthetic and toxic agent as ether, and Waller has confirmed this observation.

Syme's one rule in chloroforming was, "Watch the breathing;" and too much importance cannot be attached to it. Professor Macewen well says: "Let the sound of each respiration be registered on the tympanum of the administrator."

The colour of the ears and lips is of great assistance in estimating the vaso-motor tone. Too great a readiness to feel the pulse when giving chloroform is to be avoided. It varies a great deal during the conduct of an anæsthesia, and constantly feeling it may cause a great deal of unnecessary anxiety and mislead one. A bad pulse may be caused from too little chloroform and also from too much.

The experienced anæsthetist judges of the condition of the patient from no single sign, but from the breathing, condition of pupil, colour of lips, amount of chloroform given, the type of the patient, and nature of operation.

Stages of Anæsthesia.

Somewhat arbitrarily chloroform anæsthesia and its induction have been divided into four stages or degrees.

It is always difficult to draw a hard and fast line between one stage and another in any particular case, but for purposes of convenience, &c., there are generally considered to be four stages. It is undesirable that the administrator should be practically acquainted with the fourth and last stage, but his recognition of the first three will be necessary, for, as will be seen later, different depths or degrees of anæsthesia will be required for different operations and stages of operations.

First Stage.—The patient swallows and coughs slightly, is often restless, and turns his face if possible away from the anæsthetic—if it is too closely applied he will hold his breath, and inevitably a long sighing inspiration or gasp will

follow. Flashes of light, buzzing or hammering,* rhythmical, and developing into a mere ringing in the ears, are experienced. A curious and indescribable thrilling sensation is felt throughout the body, the general effect being somewhat exhilarating. Thoughts and ideas occur in rapid succession and in the most vivid manner.

The patient in the latter part of this stage is usually analgesic, without being in a really anæsthetic condition; he is conscious of his surroundings, but unconscious of pain.

Second Stage.—The patient now becomes rapidly unconscious. He will mutter, laugh, and talk nonsense, and respond to any questions, but not in a rational way. His conversation is usually in regard to something in connection with his occupation. Thus a soldier will quote something from the drill-book; a housewife will discuss some domestic matter in a garbled way, or make some nonsensical inquiry of her doctor. Struggling will now commonly occur, particularly in the male sex, and all alcoholics, especially if the chloroform is pushed. The face will flush, the pulse increase in rapidity, the pupils are dilated and mobile, and a marked conjunctival reflex is still present. There is a tendency to sickness in this stage, particularly if it is dwelt over, and any pallor or depression of the circulation should be taken as an indication for more chloroform. If the patient flushes and struggling occurs, the chloroform should be withdrawn, and the patient's efforts passively resisted until the anæsthesia deepens, as it will, and the struggling subsides.

Any mechanical restraint, such as strapping, &c., is better avoided if possible.

Third Stage.—The patient now becomes completely anæsthetised. The breathing becomes regular and automatic,

* Recently the author was giving a woman chloroform, and she said several times, "Oh, stop that hammering!"

like that of a sleeping person, often with a soft, quiet snore. The pupils contract usually to a diameter of 2–3 mm., but this is by no means invariable, and they should react sluggishly to light. The lid reflex has disappeared. The muscles throughout the body are relaxed. The pulse is somewhat slower than normal and more compressible. The eyeballs are usually fixed in a horizontal plane, or rotating very slowly from side to side. The administrator should beware of being misled by the condition of "false anæsthesia." This is particularly common in children, and is probably due to the patient simply going to sleep. There is a tightly contracted pupil, usually smaller than the typical chloroform pupil, the breathing is quiet, regular and automatic, and conjunctival reflex absent. A sharp pinch, a prick, or the primary incision will wake the patient completely up, and reveal to the chloroformist the painful fact that he is still practically in the first stage. When the pupil, therefore, is very contracted, the administrator must be on his guard, and have recourse to a sharp pinch before telling the surgeon that he may proceed. To recapitulate briefly, the four signs of the establishment of full chloroform anæsthesia are:—

(1.) Automatic respiration.

(2.) Loss of conjunctival reflex.

(3.) A fixed and more or less contracted pupil.

(4.) Muscular relaxation.

Unless these are present, in the very large majority of cases no operative procedure should be undertaken.

A few words are specially needed as to *the treatment of young children.* The breathing here is all-important; little reliance can be placed on the pupil, and less on the conjunctival reflex. A useful sign, however, is the rotation of the eyeballs, which commonly occurs on the advent of anæsthesia, downwards upon a horizontal axis. In very young children, also, in the early stages, the fingers will clasp tightly on any object, such as the nurse's finger, placed on the palm. This

is due to a sort of hereditary prehensile instinct. As the anæsthesia deepens, the fingers relax. "False anæsthesia" is particularly common in children. The ruling principle, however, in dealing with them must be "err on the safe side," and give too little rather than too much chloroform, for reflex troubles do not commonly arise, and the real danger is absolute chloroform poisoning; that is the production of the

Fourth Stage.—Impairment or complete cessation of respiration; an abnormally slow, feeble, or running pulse, tending to become irregular or imperceptible; moderately to widely dilated *fixed* pupils; complete absence of lid reflex; dusky pallor of complexion and separation of eyelids: such are the indications of *overdose* of chloroform.

If the administration is conducted rapidly and recklessly, and without the absolutely essential precaution of giving plenty of air, the patient may die so suddenly that the order in which the fatal symptoms arose cannot possibly be recognised. This occurs sometimes quite at the beginning of an operation. Perhaps the case is one of tooth extraction. The patient does not go under easily; he is well dosed with chloroform, and just at the first tooth he turns pale or ashy gray and stops breathing. He is often said to have died from cardiac failure or shock, when it is simply undetected asphyxia *plus* excess of chloroform. How death occurs also in such cases from shock during imperfect anæsthesia will be shown later on.

Physiological Action of Chloroform.—The essential characteristic of chloroform anæsthesia is *depression.* Paralysis of the respiratory centre is the most usual cause of death in fatal cases, but is often accompanied or immediately followed by paralysis of the cardiac centre, while primary cardiac failure is not unknown.

Chloroform anæsthesia affords an excellent opportunity of

studying the action of the drug on the various centres of the nervous system, from the highest downwards. The first parts to be stimulated are the cerebral centres with mental functions, the control of special senses, and consciousness; and these also are the first to be depressed and annulled. The lower cerebral and spinal centres are affected less and somewhat later, so that a certain degree of excitement of these accompanies the first cerebral depression, and the spinal centres being no longer controlled by the cerebral, irregular, excessive movements of the limbs ensue. As the depression deepens in the spinal centres, the muscles are paralysed. Lastly, the lowest centres of all, those connected with organic life—connected with the heart, vessels, respiratory organs and sphincters—situated in the medulla and cord, yield to the action of chloroform. Although affected from the first, it is not until higher parts have been completely overpowered that the functions of these vital centres are seriously impaired and death threatens. It is on account of the safe order of invasion of the different centres by chloroform that it has been selected as the proper agent for temporarily arresting consciousness. There are many other powerful drugs which equally depress the nervous system, but in a reverse order.

The peripheral nerves are affected last, and the loss of sensibility is due to a central and not a peripheral effect. The muscles are finally affected directly as well as through the nervous system.

The Pupil during Anæsthesia.—The pupil is a most valuable aid to the administrator, as enabling him to determine with some exactitude, taken along with other signs, the stage of anæsthesia in which the patient is.

On the application of chloroform to a patient for inhalation, the pupil rapidly dilates from stimulation of the sympathetic. As soon as the patient loses consciousness and begins to breathe more regularly and deeply, the pupil as a rule gradually decreases

in size, due to stimulation of the oculo-motor nerve by the drug, and in a normal case of chloroform anæsthesia usually contracts until it is about 2·5 mm. in diameter.

Push the anæsthetic further, and it will dilate again, being fixed and not responding to the stimulus of light. Here the dilatation is due to paralysis of the third or oculo-motor nerve

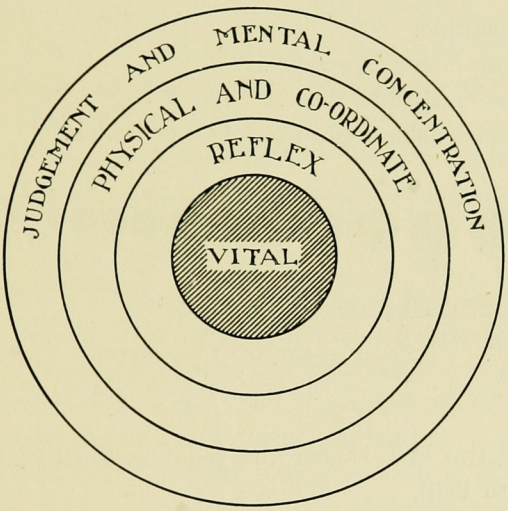


FIG. 25.—DIAGRAMMATIC REPRESENTATION OF INVASION OF NERVE CENTRES BY CHLOROFORM.

(In true chloroform anæsthesia all the centres but the vital—centres of circulatory and respiratory organs—are paralysed.)

and thus of the sphincter pupillæ, and the patient is in a dangerous condition.

Much the same may be said of the pupil in ether anæsthesia —but here the pupil does not contract so markedly as with chloroform, being usually about 3·5 mm. in diameter in good anæsthesia. The ether may be pushed beyond this stage, however, and the pupil become somewhat dilated and fixed without any degree of danger. When the pupil becomes *small—i.e.*,

less than 3·5 mm.—and mobile, with ether anæsthesia, the patient is lightly under and will rapidly come out or vomit if the anæsthetic is not rapidly re-applied.

Less reliance can be placed on the pupil when using ether than with chloroform, and with neither can it be of much use until the anæsthesia is fairly established.

Under chloroform the pupil dilates from four causes—

(1.) Vomiting.
(2.) Vaso-motor depression.
(3.) Too much chloroform.
(4.) Commencing asphyxia or CO_2 poisoning.

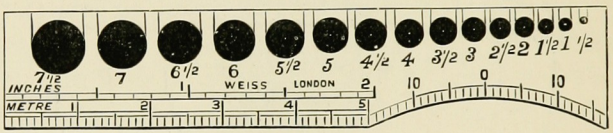


Fig. 26.—Browne's pupillometer.

In the two first named the pupil is usually mobile and responds to light.

In the two later (which often co-exist) the pupil is immobile and does not respond to light.

Recapitulating.—During chloroform anæsthesia a dilating and mobile pupil indicates need for more chloroform.

A dilated and fixed pupil means "Stop the chloroform, remove any possible obstruction to the air-way, such as a tongue fallen back, and be on your guard generally."

What are the troubles that are apt to arise during chloroform anæsthesia apart from chloroform poisoning?

(1.) Cessation of Respiration.
(2.) Cardiac Failure.
(3.) Vomiting.
(4.) Passage of Food, Mucus, &c., into Air-Passages.

I.—Cessation of Respiration Apart from Overdose.

Obstructed breathing during the administration of chloroform is especially prone to occur in highly nervous, in muscular, and in alcoholic subjects. During the second stage of chloroformisation it demands special care. The abdomen may be hard, the chest fixed, jaws clenched, and tongue pressed against the palate and pharynx, and respiration may become completely arrested for a while. The arrest is the result of muscular spasm, and the air-way actually becomes temporarily closed. It is directly after this condition that overdose is apt to occur. By holding his breath the patient raises the intra-thoracic tension. Through this the venous system is congested and less blood pumped into the arteries; the arterial tension is lowered, and less blood is supplied to the coronary arteries. Also, owing to no breathing going on, less oxygen is supplied to the lungs, and so the supply to the cardiac muscle is of poor quality, and the heart is *pro tem.* asthenic. On the relief of the obstruction, or when the patient starts breathing again, two or three deep inspirations are taken, and if chloroform has been freely poured on to the inhaler, a large dose is inspired. Some of it at once passes into the coronary arteries to an already enfeebled heart, which, by this poisonous overdose, is thrown into a state of paralytic dilatation from which it rarely recovers. This is one of the most common ways in which death occurs in early stages of chloroformisation.

A slight movement of the patient's arms and hands during chloroform anæsthesia is not by any means always to be taken as a sign of the patient coming out. It is not uncommon for the arm or arms to be more or less rhythmically jerked, by a sort of clonic spasm, towards the middle line, while the fingers are alternately flexed and extended.

Athetotic Movements.—This may be due to spasm of the pectoral and other muscles, and indicate a pressing necessity for more air and less chloroform. The automatic and perhaps

stertorous breathing of the patient, combined with a dilating and fixed pupil, enable one to differentiate between this condition and the mere gesticulations of a patient who is only semi-anæsthetised.

There is one form of respiratory obstruction which the student will meet with in all probability in his first case of chloroform—simple falling back of the tongue. Relaxation of muscles is one of the normal and necessary accompaniments of true anæsthesia, and, along with the other muscles, the elevators of the tongue relax, and allow it to slip down and back and partially occlude the opening of the larynx. The slight stertor caused by this is not to be regarded as an indication for immediate tongue traction. It is a characteristic sign of the tyro to commence fishing away in the mouth for the tip of the tongue directly this phenomenon occurs. The proper treatment is to get the fingers well behind the angle of the jaw and drag it forward; the muscles of the base of the tongue are attached chiefly near the symphysis of the Inf. maxilla, and so, by dragging it forward, these are put on the stretch and the tongue raised. If the jaw is "underhung," some difficulty may be experienced in getting it well forward, and the aid of a mouth wedge or Mason's gag may be needed.

Spasm of the glottis due to approximation of the aryteno-epiglottidean folds is seen in adults, but more commonly in children. It gives rise to loud crowing breathing and to increasing cyanosis. The condition is usually relieved at once by rhythmical tongue traction.

II.—Failure of Circulation Independent of Overdose:—

(1.) From fright or shock before true anæsthesia in highly-strung nervous subjects.

(2.) During light anæsthesia from actual or threatened vomiting.

(3.) From partial asphyxia—that is, secondary to respiratory obstruction.

(4.) Due to strain of the operative procedure, excessive hæmorrhage, or withdrawal of fluid from abdomen or chest.

(1.) Fainting and collapse during early stages of inhalation are by no means uncommon, and death from syncope may occur. The anæsthetic is not altogether to blame, for, prior to the introduction of anæsthetics, death from fright, either before or at the commencement of an operation, was by no means unknown. The primary cause of death is excessive emotion and fear. We see cases of death occurring in this manner recorded in the public press, and very often emphasis is laid on the small amount of anæsthetic given, but in this really lies the danger. The more rapidly such patients are got under the better, and hence the advantage of the rapidity of gas and ether in producing anæsthesia.

(2.) During light anæsthesia from threatened vomiting, &c. All troubles during anæsthesia are more prone to occur during light narcosis. The reflexes are not subdued completely, and the activity of the vomiting centre may give trouble. Why chloroform causes early vomiting in some patients and not in others is difficult to explain, but the fact remains. Sickly, pale, unhealthy girls are specially apt to give trouble in this way. The onset of vomiting is signalised by swallowing movements, sudden pallor, and dilatation of the pupil; the pulse may become very shabby, and breathing shallow. The patient's face must be turned to one side and the chloroform *pushed*. As in the large majority of cases the patient has been fasting prior to operation, there is nothing much to come up—at least nothing solid. It is surprising, however, how much fluid matter, composed of swallowed saliva, mucus and bile regurgitated from the duodenum, some patients can produce. If the case be an emergency one, and there is a possibility of a recent meal, it is best to let the patient be thoroughly sick while he is about

it. Raise the right shoulder and turn him well over on his left side. After he has vomited, see that there is no solid matter hanging about mouth or pharynx, and proceed to get him well under. In patients suffering from heart disease, especially aortic disease, or even cardiac asthenia, there is considerable risk of syncope during vomiting.

(3.) The danger of cardiac failure, secondary to obstructed respiration and partial asphyxia, has already been referred to, and the treatment is simply prevention of the antecedent condition.

(4.) Failure of circulation, from the strain of the operation and continued use of chloroform, is by no means uncommon in prolonged operations. As has already been stated, the key-note to the physiological action of chloroform is *depression*.

How long the human organism can sustain this depressant action on the circulatory mechanism will entirely depend on the personal factor—on the presence or absence of a good constitution in the patient operated on.

Death occurs :—

I. From overdose—either

(1.) Overdose acting on an anæmic and asthenic heart during struggling stage—*i.e.*, syncope; *or*,

(2.) Overdose, pure and simple, during course of a long anæsthesia.

II. From syncope, caused by upright position of patient during chloroform anæsthesia.

III. From reflex cardiac inhibition;* syncope or shock during light anæsthesia—*e.g.*, in dental cases, operations on the rectum, or castration.

IV. From partial or undetected asphyxia, with an amount of chloroform normal or non-toxic under ordinary circumstances.

* Dr. Embley, Anæsthetist to Melbourne Hospital, has fully demonstrated that cardiac inhibition from the vagus does occur.—*British Medical Journal*, 8th, 15th, 22nd April 1902.

The Advantages of Chloroform.—Chloroform is indispensable, in spite of its drawbacks. Notwithstanding all that has been truly advanced against it, chloroform always has been, and probably it or mixtures of it will largely remain, the drug for producing anæsthesia which the general practitioner most commonly uses. The following advantages may be fairly claimed for it:—

(1.) It is pleasant in smell, and *seems* easy to administer. It produces little or no choking, so that even children often inhale it without demur or resistance.

(2.) No special apparatus required to obtain the best results.

(3.) Smallness of quantity required owing to high narcotic strength. In most cases anæsthesia is produced by a small quantity, and thus the bulk of the amount to be carried in the practitioner's bag is small.

(4.) Quiet anæsthesia. Once the anæsthesia is produced, the patient lies completely relaxed and breathing quietly, and the absence of abdominal respiration and excessive movement is a distinct advantage in abdominal operations.

(5.) Chloroform is non-inflammable and less volatile than ether. In tropical countries ether evaporates so rapidly that it is extremely difficult, if not impossible, to anæsthetise a patient with it except with a closed inhaler; also it is difficult to store, for a bottle of it, if not hermetically sealed, rapidly empties itself by evaporation.

The Disadvantages of Chloroform.—A great deal can be said against chloroform.

(1.) The high rate of mortality among patients put under its influence. We find that out of every thousand persons anæsthetised with chloroform one succumbs, and that the conclusion drawn from laboratory experiment as to this drug being ten times as toxic as ether is confirmed in every-day practice.

(2.) It appears to possess what may be almost termed a

selective action on the circulatory apparatus. Both man and animal show signs of progressive lowering of blood pressure and weakened heart action under its influence.

Sudden and unexpected diminution of blood pressure may occur at any time during chloroform anæsthesia:—

(*a*) At the commencement of the administration just after the repetition of a dose; (*b*) while the patient is fully anæsthetised and the drug is evenly given; (*c*) late on, in a prolonged surgical operation, or even after the administration has ceased for some time and the influence of the drug is passing off. At no moment can we be sure of the heart during the administration of chloroform.

(3.) Chloroform is essentially depressant to animal vitality, and is a *protoplasmic poison.* In some cases it causes fatty degeneration of the ganglionic cells of the heart, and of the cardiac muscle fibres; also of the muscle cells throughout the body; of the cells of the viscera and glands; and of the coats of blood-vessels; and these changes may produce fatal results long after the administration (Stiles). These facts constitute a strong argument against the routine use of chloroform for anæsthetic purposes, the truth and force of which cannot be denied, although, where its use is indicated, care and proper management can greatly lessen all its dangers.

(4.) Tendency to decompose and give off irritating and poisonous vapours in the presence of a naked light.

The After-Effects of Ether and Chloroform.

I. Vomiting, retching, and nausea are the most frequent and worthy of note. The vomiting may vary from a severe and prolonged kind, lasting three or four days, to transient nausea and slight retching with a little mucus. Much depends on the digestive history of the patient, and the care and precaution exercised in preparing him for the operation; the

amount of the anæsthetic and the manner of its administration can also have some influence. A patient will commonly suffer from more severe sickness after two hours' chloroform for a severe abdominal section than after four or five minutes' anæsthesia for opening an abscess or evulsion of a toe-nail. When administering ether, a great deal depends on the amount of air which the patient is allowed during the anæsthesia, and the maintenance of good colour at least after the initiatory stages. Accordingly, as far as possible, the bag of Clover's inhaler should be removed as often and for as long as possible when once the patient is completely anæsthetised. By so doing, constant cyanosis and slight carbonic acid poisoning are avoided. There can be little doubt that the worst forms of vomiting seen after ether are due to want of this precaution, and the headache sometimes experienced is similar to that which is produced by sitting for a long time in a small ill-ventilated apartment or at a smoking concert. There seems no more reason why a patient should be sick after ether when he has emerged from its anæsthetic effect and got rid of the ether-impregnated mucus which he has swallowed, than after a fairly large dose of alcohol. Chloroform, on the other hand, has a very strong tendency to produce nausea and sometimes severe sickness, not from any local irritating action on the digestive apparatus, but interference with the functions of the liver and the general metabolism. The vomiting is not of nervous origin, but is essentially *toxæmic*, due to profound depression of the hepatic function, with consequent diminution of its antitoxic powers during the period of administration. This depression is greater if the liver is already weakened by disease

or poor nutrition, and will also be accentuated if food is withheld too long a period before the anæsthesia. Dr. Wm. Hunter considers that too much fasting is responsible for many cases of secondary chloroform poisoning. There can be no doubt that the severe vomiting which we not uncommonly see after chloroform, going on in some cases to hæmatemesis, is merely a sign of an early stage of delayed chloroform poisoning, which, unless carefully treated with washing out of the stomach, &c., may end fatally.

II. Albuminuria, nephritis, and uræmia have been known as sequelæ to etherisation. There is little doubt, however, that there was in most cases pre-existent renal disease, and that neither chloroform nor ether has the power of producing anything more than a transient albuminuria, where the kidneys are previously in a really healthy condition. As, however, ether raises the blood pressure, and stimulates the kidney, often causing some polyuria, it is undesirable to administer it in some conditions of renal incompetency, and chloroform (or the CE mixture) is here preferable.

III. Glycosuria and acetonuria.

It has been for a number of years known that the administration of chloroform was occasionally followed by glycosuria, but the recent investigations of Dr. Lewis Beesley have shed much light on this subject, and are of the utmost importance to the public and medical profession alike (*British Medical Journal*, May 1906). Dr. Beesley has been for two years making investigations in connection with this subject, chiefly carried out at the Royal Hospital for Sick Children, Edinburgh. His results absolutely confirm the previously published observations of Stiles and M'Donald on secondary chloroform

poisoning, and, summed up, they are as follows: He found that—

(1.) Both ether and chloroform invariably produce a temporary acute acetonæmia, which may be very detrimental even to an apparently healthy organism.

(2.) Two separate conditions should be recognised, viz.: acute and chronic acetonæmia.

(3.) Acute acetonæmia is accompanied by symptoms of acid intoxication, sometimes ending in death when the kidneys are unable to cope with the increased formation of acetone by a corresponding capability of excretion.

(4.) Although ether may produce a greater acetonæmia, this is less harmful than that produced by chloroform, because ether is less injurious to the cells of the liver and the kidneys, and thus does not interfere with their power of elimination.

(5.) The more plentifully and rapidly the excretion is carried on the less serious the poisoning.

(6.) The effects of the toxæmia are mitigated by the administration of alkalies, which may be given also with advantage before the operation—if poisoning is anticipated.

(7.) The risks which are usual in anæsthesia are not increased by pre-existent *chronic* acetonuria.

(8.) Anæsthesia is dangerous with pre-existent acute acetonæmia, especially if the anæsthetic be chloroform.

(9.) A guarded prognosis must always be given when acute acetonæmia is present with symptoms of poisoning.

(10.) Death following the administration of chloroform with symptoms of poisoning may be due to idiosyncrasy of the patient.

The importance of Dr. Beesley's work can scarcely be over-estimated.

It seems established beyond the shadow of a doubt,

that in hundreds of cases where death has occurred in from two to three days after operation, and has been attributed to "septic intoxication," it has been due to nothing more nor less than an acute acetonæmia caused by the inhalation of chloroform and failure of the kidneys to excrete the acetone with sufficient rapidity to prevent coma and death.*

The lesson to be drawn is to use chloroform as seldom as possible when the operation can be properly performed under ether. If we add the risks of acetone poisoning (for bad cases of which it seems practically impossible to do anything in the way of treatment) to an immediate mortality of 1 in 1000 under chloroform, it is perfectly obvious that it is an exceedingly dangerous drug to employ. It should especially be avoided in all severe abdominal cases where suppuration has begun, or seems likely to have begun. Cases of tubercular adenitis seem also to be particularly prone to become the subjects of acute acetone poisoning.

IV. Ether is more apt than chloroform to produce temporary mental and even maniacal excitement, and accordingly, when dealing with the insane or those having any tendency to insanity, chloroform is best where local anæsthesia is not sufficient.

V. "Ether Bronchitis" is the pet bugbear of those who

* A case of this nature, absolutely typical, has recently come under the author's immediate observation. A girl of 21 was operated on for appendicitis in the quiescent stage. Chloroform was the anæsthetic. The operation was an extremely simple one, rapidly done, and carried out with rigid antiseptic precautions.

Vomiting commenced on the afternoon of the operation, and never ceased practically until death occurred in some 48 hours. The temperature rose to 105° before death, and the various characteristic symptoms described by Dr. Beesley were present. The urine was examined shortly before death, and was free from acetone, the kidneys having obviously failed to deal with the great amount of acetone in the blood.

advocate the exclusive use of chloroform, and the frequency of its occurrence has been greatly exaggerated, chiefly by persons having very little, and sometimes no practical experience of ether anæsthesia.

Personally, the author has never had a patient die from this cause, nor has he seen more than a very few cases altogether out of several thousand anæsthesias. In twenty years of private practice, during which time he was using ether almost to the exclusion of chloroform, Mr. Pridgin Teale of Leeds only noted one case of bronchial trouble.

There is no doubt that bronchitis and broncho-pneumonia do occur occasionally after ether administration, but they are more common in hospital than private practice, which is probably due to the following causes:—

I. The operating theatre may be at too low a temperature; or,

II. While the theatre itself is sufficiently warm, the patient, while still under the influence of the anæsthetic, is taken through a cold corridor back to the ward, and placed in his bed (possibly near an open window). This the author actually knows to be the case in an hospital where "ether-bronchitis" is of unduly frequent occurrence.

III. Septic pneumonia or bronchitis from dirty inhalers, or from some septic discharge from the nose, pharynx or mouth—*e.g.*, after tooth extraction, has often been attributed to ether.

An error in investigating these cases also arises from the fact that a certain number of cases admitted to hospital for operation will develop respiratory trouble, either in the shape of bronchitis or pneumonia, even if no anæsthetic be given. Further, in patients who previously suffered from bronchitis it sometimes recurs.

The proportion of patients suffering from true ether bronchitis is a very small one, provided the anæsthetic is properly administered, and the operating-room, &c., kept at a proper temperature.

CHAPTER VI

NITROUS OXIDE AND ETHYL CHLORIDE SEQUENCE. NITROUS OXIDE AND ETHER AND ETHYL CHLORIDE AND ETHER SEQUENCES. ANÆSTHETIC MIXTURES

Nitrous Oxide and Ethyl Chloride.—This combination has several advantages, chief among which is the fact that after-sickness is less frequent than after ethyl chloride when administered alone, only occurring in about 5 per cent. of the cases; and, further, many patients prefer to lose consciousness by means of gas, as the odour is fainter and much less noticeable than that of ethyl chloride.

The technique is extremely simple. A one-gallon bag is filled with nitrous oxide gas, stopping short of distension, and then 3, 4 or 5 c.c. of ethyl chloride are introduced into this after the patient has had five or six breaths of the gas, either through a special inlet in connection with the stop-cock, or by means of a special small test-tube containing a measured quantity of ethyl chloride attached to the lower extremity of the bag, as suggested by Dr. Hewitt. The duration of the anæsthesia will vary with the amount of the drug used.

With 5 c.c. of ethyl chloride and 1 gallon of gas inhaled for 90 seconds an anæsthesia of 1½ to 2 minutes may be expected. There is extremely little alteration of the patient's colour, and there should be no jactitation, so that the character of the anæsthesia is a much pleasanter one than that obtained with pure nitrous oxide.

Nitrous Oxide and Ether Sequence.—Ether may be advantageously preceded by one of the minor anæsthetics, the

advantage being that the patient is more rapidly rendered unconscious, without being subjected to the unpleasantly pungent smell and taste of the ether during the period of induction. Further, much time is saved, and practically all struggling avoided.

There are two distinct ways of using nitrous oxide and ether:—

(1.) Simply getting the patient partially anæsthetised with nitrous oxide, and then, before jactitation appears, passing the gas over the ether in the reservoir, keeping the indicator at F. for a period of from a half to one minute according to the length of anæsthesia required. The anæsthesia so obtained is a true "gas and ether" type. This must not be confused with—

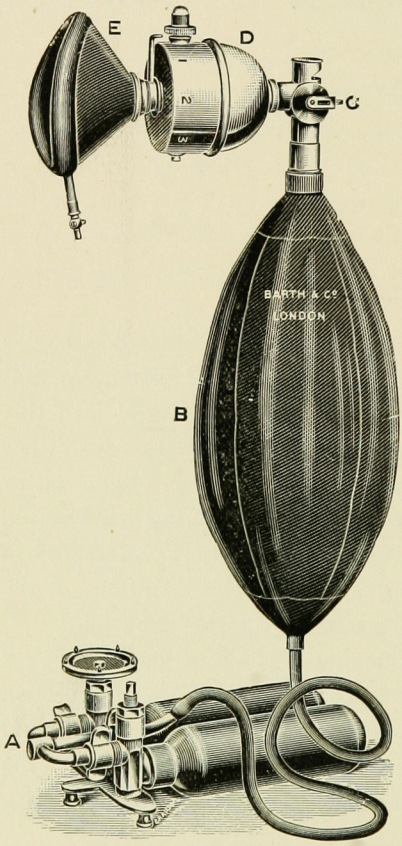


Fig. 27.—Gas and ether apparatus.

(2.) Ether anæsthesia preceded by nitrous oxide (Dr Hewitt's method), where a three-gallon bag attached to a Clover is filled with nitrous oxide, and simply used to render a patient unconscious for, perhaps, a prolonged operation under true ether anæsthesia.

Neither of these methods is well suited for children under ten years of age, as the somewhat extensive apparatus is rather apt to frighten them. For such patients the

Ethyl Chloride and Ether Sequence is much better adapted, and it is rapidly growing in favour at the present time for all classes of cases for which ether is suitable. It can be used in both the ways just described in regard to nitrous oxide, and we get a true ethyl chloride ether anæsthesia in the one case, and an ether anæsthesia preceded by ethyl chloride in the other. As regards the dose of ethyl chloride, about 3 c.c. to 5 c.c. will be sufficient, according to the age of the patient. The best method is to charge a Clover's inhaler with ether, and then, carefully keeping the indicator at O, introduce 3 c.c. to 5 c.c. ethyl chloride into the bag (by means of a special aperture); apply the inhaler to the patient's face, and after allowing six good inspirations of ethyl chloride, which will occupy about 20 seconds, begin to turn on the ether, at first slowly, and then more rapidly, so that in the majority of cases a good anæsthesia is obtained in 2½ to 3 minutes. In this method the patient usually loses consciousness before the ether is perceptible, and coughing and delay from respiratory hesitancy are avoided.

Care must be taken to use neither too little nor too much ethyl chloride, the first mistake will cause delay in inducing anæsthesia and discomfort to the patient, and the second an undue amount of stertor, with rigidity and possibly marked respiratory spasm. Very seldom will more than 5 c.c. be needed.

Anæsthetic Mixtures.

With the tendency to undue circulatory depression, on the one hand, under chloroform, and the tendency to too profuse secretion of saliva, and to spasm, under ether, it is often found advantageous to use a mixture of these anæsthetics in certain cases, as it is found that a suitable combination so far presents the advantages of both anæsthetics, while the disadvantages are largely neutralised.

The ACE mixture suggested by the late Dr. George

Harley has found much favour. It consists, as might be supposed, of

Alcohol . . .	1 part
Chloroform .	2 parts
Ether . . .	3 parts.

Objection has been taken, however, and we think rightly, to the presence of the alcohol in such a proportion, as it is obvious, even *theoretically*, that it cannot evaporate at the same rate as the other constituents of the mixture, and, practically, we find this confirmed, as, after using such a mixture for some time, the fabric used as the inhaler becomes completely saturated with unevaporated alcohol.

The most generally serviceable mixture is one of chloroform 1 part and ether 2 parts, or simply the ACE mixture with the alcohol omitted, according to the type of our patients, as for the more robust and the alcoholic it is advantageous to employ a rather larger proportion of chloroform in the mixture.

Throughout these pages, where the term CE is used, a mixture of 1 part of chloroform to 2 of ether is meant.

The Anæsthesia is of the chloroform type. The breathing is more easily heard than when chloroform is employed, but not of so robust a character as when the patient is under ether. The pulse is fuller than under pure chloroform, but has not the bounding character of an ether pulse. The pupils are midway between ether and chloroform pupils in size. Salivation and secretion of mucus are slight in amount compared with what is sometimes seen with ether, but rather more common than under chloroform, especially in children.

The Inhaler.—Except when dealing with young children, it will, as a rule, be found advantageous and economical as regards the anæsthetic to use some form of open inhaler for the CE mixture.

For young patients and the feebler types of patients a Schimmelbusch mask (with *two* layers of lint) will answer quite well, but with the more robust types and alcoholics the case is different, and one of the open cone inhalers is desirable, and even necessary.

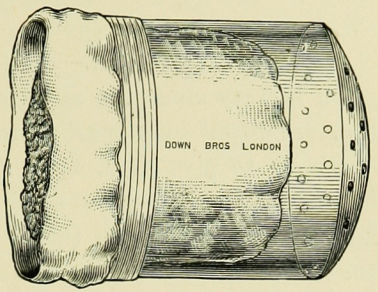


Fig. 28.—Rendle's mask (celluloid).

Rendle's mask and the Hyderabad cone have both been much used, but are open to objection, as they cannot be readily sterilised, and so may convey infection from one patient to another.

The perforations in this apparatus are very apt to be too small to permit of sufficient air-supply. The former has now been made of celluloid, and this form is to be recommended. To avoid dripping of the anæsthetic, it is necessary to put it in small quantities at a time on the sponge, and not on the flannel lining. We have for some time, however, been experimenting with various of the inhalers for mixtures on the market, and have come to the conclusion, after a prolonged trial, that the most generally useful, and the one with fewest drawbacks, is Blake's inhaler, first introduced by Mr. J. Bapst Blake of Boston, which we have modified to some extent.

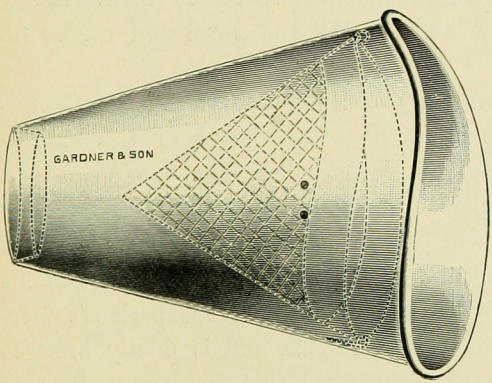


Fig. 29.—Cone inhaler for CE mixture.
(Modified by Author from Blake's.)

It is described elsewhere in this volume under "Ether," but when using it for the open administration of ether, it is advantageous to use a rubber face-pad, which is inadmissible when giving a mixture containing chloroform.

The Administration.—Mixtures containing chloroform are given in very much the same way as chloroform itself, but as they are, to all intents and purposes, diluted chloroform, it is necessary to give them more freely. Care must be taken, however, not to put on too much at one time, as the absorbent fabric in the inhaler will then become supersaturated, and the anæsthetic drip down over the patient's face and cause blistering. Moreover, if the mixture be too freely applied, the patient will at one time be inhaling almost pure ether, and then a fairly strong chloroform vapour, as the ether evaporates more rapidly than the chloroform. When using Blake's cone, it is useful, as a precaution against blistering, to have a corner of a towel tucked up between the edge of the inhaler and the patient's face, so that, if the anæsthetic is inadvertently allowed to drip, it is absorbed by the towel and causes no blistering.

It requires considerable practice to use one of these cones skilfully, so as to maintain an even vapour of CE, and to prevent any of the anæsthetic from dripping.

As regards the quantity put on, a drachm is about the average to aim at (it will be remembered that with chloroform half this amount is recommended). After putting this amount on, the inhaler is gradually brought near the patient's face, so as to accustom him to the vapour, and is finally brought quite close, but it is so constructed that it always allows a certain amount of air to be admitted in addition to that which enters at the open top of the cone.

To the medical man not thoroughly accustomed to anæsthetics the CE mixture presents many real advantages. If we exclude the very worst alcoholics, there is practically no

type of patient in whom a very good anæsthesia cannot be induced and maintained by means of it. There is always less risk of trouble arising with the circulation than when pure chloroform is used, and in any case the onset of any difficulty is less sudden, and treatment more commonly efficacious.

As regards the after-effects, *vomiting* is rather more common than after chloroform or ether.

CHAPTER VII

ANÆSTHETIC APPARATUS IN GENERAL PRACTICE

THE apparatus of which a doctor in general practice should be possessed for anæsthetic work will largely depend on the character of his practice, and the frequency of the calls on his anæsthetic skill. This being so, however, there is an irreducible minimum without which the administration of an anæsthetic should on no account be undertaken.

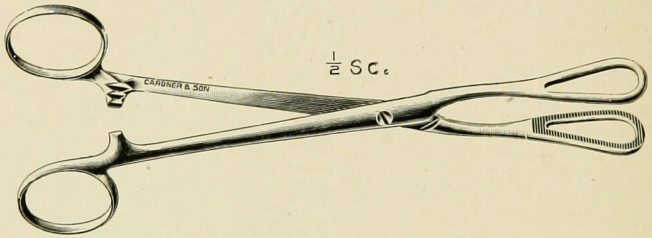


FIG. 30.—GUY'S PATTERN TONGUE FORCEPS.

A medical man about to give an anæsthetic should be possessed of the following articles, and have them immediately at hand:—

(1.) The anæsthetic agent—chloroform or ether, *both* if possible; if one only, then chloroform.

(2.) Some means of exhibiting the drug—a towel or napkin —*à pis aller*—or better, one of Schimmelbusch's masks.

(3.) A tongue forceps of some kind. Guy's pattern is the best, but, failing this, a dressing forceps or Kocher artery forceps does very well. If obtainable, one *without* a take-off joint is to be preferred.

(4.) Some means of opening the patient's mouth in case of masseteric spasm. An ordinary wooden wedge,

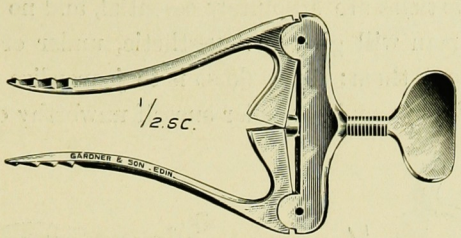


FIG. 31.—MOUTH-OPENER (HEISTER'S).

supplemented by a Mason or Ferguson's gag, is best.

(5.) A drop bottle for the chloroform. Symond's and Mill's

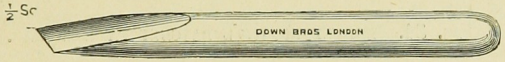


FIG. 32.—WOODEN WEDGE.

are the best patterns, but one can be easily and economically improvised with a four-ounce round-shouldered bottle and the stopper of a perfume bottle.

(6.) A hypodermic syringe with two needles which are known to be in working order.

(7.) Some brandy or other alcoholic stimulant.

(8.) A set of instruments for performing tracheotomy, or at the very least a sharp scalpel and trachea tube.

(9.) A towel in addition to the one which may be used as a vehicle for the anæsthetic. This may be of the greatest service during the anæsthesia. It will serve to remove saliva and mucus from the patient's lips, and as a receptacle for any vomited matter,

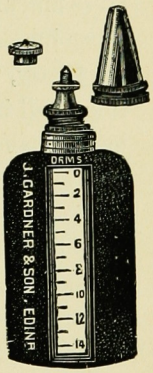


FIG. 33.—SKINNER'S BOTTLE.

while it is occasionally of great use in improving the circulation by rubbing the patient's lips briskly.

These articles are absolutely essential, and no reasonable or reasoning man will give an anæsthetic, under ordinary conditions, without them; for to do so is to jeopardise the patient's life unjustifiably, and to render oneself unworthy of confidence.

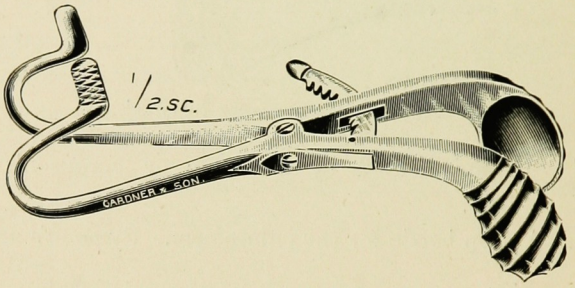


FIG. 34.—DUDLEY BUXTON'S RATCHET PATTERN GAG.

But, further, it is most desirable, and almost essential, for the practitioner to have in his possession a means of giving ether or CE—such as Blake's inhaler, while any man who has a large amount of surgery in his practice should have a Hewitt's ether inhaler in his possession and be able to use it.

Lastly, the possession of a cool head and a power of observation is all important; these cannot be purchased at the instrument makers, but the possessor of the former in anæsthetic emergencies, as in others which occur from time to time in medical practice, will rise above his fellows, and, when the patient's life is trembling in the balance, bring down the scale on the right side.

MECHANICAL ANÆSTHESIA;

or, How the Practitioner can best work Single-Handed.

Some years ago, when the Glasgow Medico-Chirurgical Society took up the question of anæsthetics for discussion, it

was urged by some members that it was most necessary and desirable that two medical men should be present during the administration of chloroform or ether, and since then Colonel Lawrie has gone so far as to say that *five assistants are needed!* * This may be possible in Utopia, but it is obvious that the country practitioner, in out-of-the-way districts, has to face, not infrequently, unaided by any skilled hand, the dangers of anæsthesia, and at the same time possibly attend to a badly fractured limb, a dislocated hip, or a strangulated hernia.

A practitioner so placed is in the most unenviable position. We will assume that his knowledge of surgical technique is all that can be desired. How can he best solve the problem of conducting a safe anæsthesia, and at the same time carry out the surgical procedure indicated? He should have some exact or mechanical method of maintaining anæsthesia, which a person quite unskilled can look after, the only attention required of him being to see, as far as possible, that the respiratory rhythm is uninterfered with.

Two methods may be used—

1. If he is fairly expert, he can give the patient ether by means of a Clover's inhaler, and get him very deeply under, "charge him up" with the anæsthetic so as to produce analgesia at least for ten, fifteen or even twenty minutes, as is quite possible with ether. He can then hand over the care of the patient's head to a groom, a mechanic, or a nurse, whose only duty will be to wipe any mucus from the patient's mouth with a towel, keep his face on one side, draw the chin forward, and warn the doctor if the breathing is failing, if the patient is getting "blue," or coming out.

Such a measure is particularly well adapted to reducing a dislocation, setting a fracture, or operative midwifery.

* Letter to B.M.A. Anæsthetic Committee, 8th January 1893.

2. Krohne's Regulating Inhaler.

This is a modification of a spraying apparatus, introduced a number of years ago by Dr. Junker for the administration of bichloride of methylene. It has been altered in various ways, and the apparatus figured here is one of the best kind made by Messrs. Krohne & Sesemann.

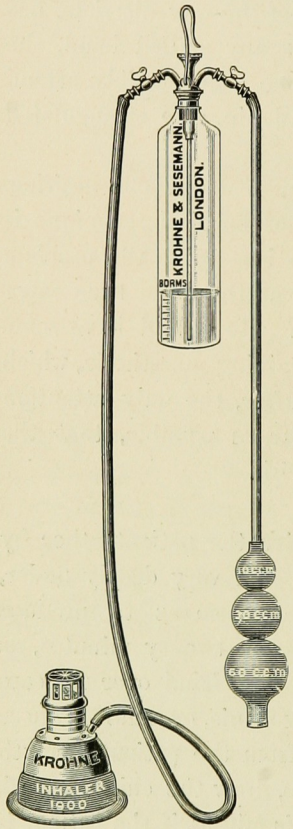


Fig. 35.—Krohne and Sesemann's new pattern regulating inhaler.

The *modus operandi* is very simple, just like that of an ordinary perfume spray. By means of the double ball [pump [a continuous supply of dilute vapour of chloroform is kept up.

Lord Lister, many years ago, carried out a series of experiments to ascertain approximately the percentage of chloroform in the vapour inhaled from a towel, as used then as a matter of routine at the Edinburgh Royal Infirmary. He ascertained, after a number of trials, that it was generally about 4 to 5 per cent. So it will be seen that Krohne's Regulating Inhaler attains this result with a minimum use of chloroform, and is certainly, for the inexperienced, a safer method of administering a drug of such power than the towel and bottle.*

To attain a degree of narcotism, in which under chloroform a surgical operation can be performed painlessly in an adult, Snow found that it was necessary for 18 m. to be absorbed.

* *Vide* footnote on Dr. Embley's researches, p. 66.

The second degree of anæsthesia is thus attained, and with 24 m. very deep anæsthesia; on 36 m. being absorbed the respiration is stopped.

The length of time which, according to Dr. Snow, it is most desirable to occupy in the induction of anæsthesia with chloroform before the commencement of an operation, is about two minutes in infants, three minutes in children, and four or five minutes in adults. Circumstances occasionally occur to lengthen these periods. The problem is, how to induce the absorption of eighteen minims of chloroform within the required time, so as to secure complete anæsthesia. To accomplish this *safely* it is necessary that the administration

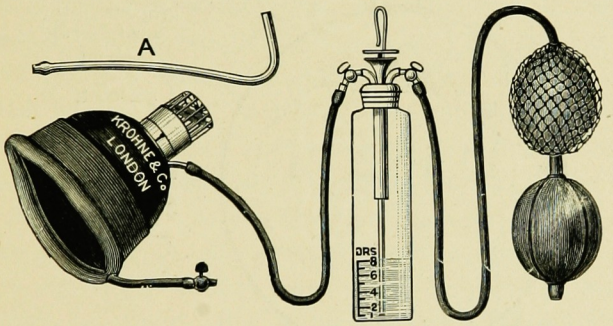


FIG. 36.—KROHNE AND SESEMANN'S INHALER (OLD PATTERN).

should be commenced, in every case, with chloroform very much diluted; there should then be a gradual and systematic increase to the largest percentage of vapour which the patient is able to inhale comfortably, with *normal and regular respiration*, until anæsthesia of the required degree is induced. Thus, during the first minute (taking the number of inspirations at twenty) there should be twenty $\frac{1}{8}$ compressions of the bellows, during the second minute twenty $\frac{1}{4}$ compressions, during the third minute twenty $\frac{1}{2}$ compressions, and during the fourth minute twenty $\frac{3}{4}$ compressions. The chloroform vapour is always projected into the air-way as inspiration commences.

The bellows or elastic ball by which air is pumped through the chloroform bottle is shown above, together with the degrees of compression by which the amount of chloroform vapour is regulated and projected into the air-way.

Administration may be commenced with about $\frac{1}{20}$, $\frac{1}{10}$, or $\frac{1}{8}$ compressions, according to the patient's physique.

"Each full compression of the bellows evaporates, at a

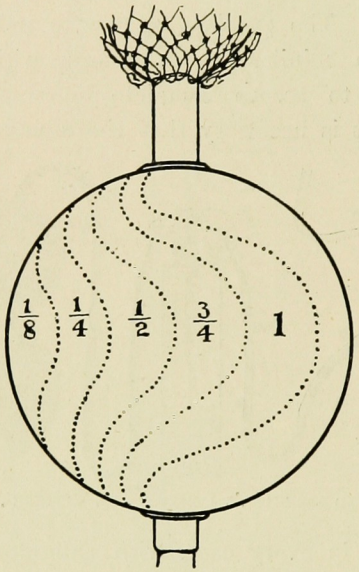


FIG. 37.—PUMP OF KROHNE'S INHALER.

(Showing amount of chloroform expressed—in fractions of minim according to strength of compression.)

temperature of 62° Fahr., one minim of chloroform on an average, and produces 1·15 cubic inch of chloroform vapour. Therefore, at the end of the fourth minute there will have been administered 32·5 minims of liquid chloroform, which gives 37·37 cubic inches of chloroform vapour. Taking the quantity of air inhaled during four minutes at 2000 cubic inches—(viz. in each minute twenty inspirations, each of 25

cubic inches), this would give an average of 1·869 per cent. of chloroform vapour to 2000 cubic inches inhaled during the four minutes; or, to each 500 cubic inches of air inhaled during the several minutes, the following percentages:—

Minutes.	Compressions.	Chloroform. Minims.	Chloroform. Cubic Inches.	To 500 Cubic Inches of Air.
1st	Twenty $\frac{1}{8}$	2·5	2·87	0·575 per cent.
2nd	„ $\frac{1}{4}$	5	5·75	1·150 „
3rd	„ $\frac{1}{2}$	10	11·50	2·300 „
4th	„ $\frac{3}{4}$	15	17·25	3·450 „
Average over the whole four minutes,				1·869 „

"Provided the compressions of the bellows have been fairly timed to the commencement of each inspiration, and the vapour is inhaled with the normal respiration of an adult, it will probably be found during the fourth minute that the required eighteen minims of chloroform have been absorbed into the blood. If not, a full compression of the bellows should be given with each inspiration during the fifth minute, until anæsthesia of the desired degree is induced. From this point onwards only small doses are required to maintain anæsthesia, as it is only necessary to introduce so much further chloroform as is required to replace what is lost by exhalation, &c., and thus to maintain in the blood that percentage of chloroform which at first was required to induce anæsthesia.

"When signs of returning consciousness are observed, a few fuller compressions of the bellows suffice to deepen the anæsthesia. The anæsthesia is at once eased off by intermitting or stopping the compressions, and without disturbing the mask.

"For children and weakly adults the administration should be commenced with even smaller doses, according to the age and state of health, say with $\frac{1}{16}$ compression, or even less. The dosage should then be gradually increased so long as the patient is able to breathe easily without cough, much less holding of the breath or struggling" (Krohne).

From the above it would appear that the administration of chloroform is reduced to mathematical accuracy. Unfortunately patients vary so much that such a method cannot be entirely relied on.* As regards the respiratory indicator — during chloroform anæsthesia the respirations are sometimes so feeble as not to be strong enough to raise the feather which constitutes the indicator. Further, in the struggling stage the apparatus may be in the administrator's way and hamper him, or may get smashed up. As regards personal experience, the author has very rarely used this inhaler except for operations in the region of the throat and nose, when the chloroform must be given through a tube so that the anæsthetist may not interfere with the surgeon's work.

In such cases it answers excellently well, and very seldom is it necessary to stop the operation and give the drug a little more vigorously for two or three minutes.

Apart from this, however, it would appear that for the absolutely inexperienced practitioner as regards anæsthetics (a person who, one trusts, will soon be out of fashion), the above is a safer and more accurate method of producing and maintaining anæsthesia. Of course the country doctor cannot be expected to go his rounds with a Krohne inhaler in his pocket, but other things being equal, if an operation, not one of emergency, is being done, he may find this apparatus of great service and comfort.

It is particularly useful in midwifery cases, and is probably the only means by which self-administration of chloroform may be allowed. The apparatus may be hung at the end of the bed and the patient instructed to squeeze the ball intermittently when a pain comes on. As soon as anæsthesia is induced the capacity or ability to keep up the puffing will cease from muscular relaxation, and so the supply of chloroform will be automatically stopped.

* It is practically impossible to get a vigorous alcoholic properly anæsthetised with this apparatus.

A number of medical men have written to the journals from time to time advocating its general employment, notably Dr. Jas. Edmunds of London, and Dr. Carter of Weymouth, who read a paper on its advantages before the Society of Anæsthetists in December 1895.

It was used for a long time almost exclusively at the Samaritan Hospital, London, and Drs. Dudley Buxton, Blumfeld, and a number of other anæsthetists use it fairly extensively in their practice.

Finally, when working single-handed, it is questionable if a medical man need give an anæsthetic such as ether or $CHCl_3$ at all in some cases—*e.g.* in severe smashes of limbs and joints, associated with much shock and loss of blood, and also in head injuries where there is cerebral compression and insensibility.

In the first case $\frac{1}{4}$ grain of morphia followed by 3 oz. of brandy will often amply suffice to deaden or entirely annul painful sensations, and in the last a depressed fragment of the calvarium may be readily and painlessly elevated with the aid of $\frac{1}{4}$ grain of morphia alone—or without any drug whatever.

CHAPTER VIII

SUMMARY OF THE DIFFICULTIES ARISING DURING ANÆSTHESIA AND THEIR TREATMENT

THE difficulties arising during the administration of an anæsthetic may be due either to:—

(1.) CIRCULATORY DEPRESSION OR FAILURE; or,

(2.) RESPIRATORY DIFFICULTY.

Frequently, of course, these conditions co-exist, but it is more convenient to consider them separately. Circulatory failure or depression may be directly due to—

(*A*) The toxic action of the anæsthetic; or,

(*B*) Some extrinsic cause, and not actually to overdose.

(*A*) **Toxic Action of Anæsthetic.**—Syncope may occur in the early stages of the anæsthesia, and more especially of a chloroform anæsthesia, owing to a relative overdose, or to cardiac inhibition caused by too strong a vapour irritating the laryngeal branches of the vagus nerve.

Later in an anæsthesia syncope occurs from too free use of the anæsthetic causing the absorption of a toxic dose, which may produce paralysis of the cardiac centre in the medulla, or of the cardiac muscle and intrinsic ganglia themselves.

The Symptoms.—Sudden pallor, rapid failure of pulse and respiration, with wide dilatation of the pupils. Pulse and breathing may cease at the same moment or within a few seconds of each other. In the early type of syncope the onset

is extremely rapid and recovery is very rare; in the later type the symptoms appear more gradually, and immediate treatment is occasionally successful.

(*B*) **Extrinsic Causes of Cardiac Failure and Depression:—**

(1.) Fright—at the very commencement of the anæsthetic.

(2.) Feeble condition of the patient existing prior to the operation, constitutional dyscrasia, exhaustion, &c.

(3.) Shock from the operation, or some procedure during it, such as twisting or cutting the spermatic cord or compressing the testicle or ovary during imperfect anæsthesia.

(4.) Reflex effect of threatened vomiting.

(5.) Sitting the patient up during the operation, or immediately after, before the effects of the chloroform have passed off.

Respiratory Difficulty.

(*A*) May be due to the **toxic effect of the anæsthetic**—*i.e.* to overdose, and is then often associated with cardiac failure.

The Symptoms are:—Pallor of an ashy grey type, shallow breathing, with failing pulse and dilated pupils.

(*B*) May be due to **Respiratory Obstruction:—**

(1.) Spasm of the muscles at the base of the tongue, or falling back of the tongue.

(2.) Spasm of the muscles of the jaw and neck.

(3.) Spasm of the aryteno-epiglottidean folds in the larynx.

(4.) General spasm of the respiratory muscles, including the intercostals.

(5.) Position of the patient—*e.g.*, the absolutely prone posture in laminectomy, trephining for cerebellar tumour, kidney operations, &c.

(6.) Foreign bodies entering the air-passages—*e.g.*, vomited matter, blood, excessive mucus, or false teeth.

The Symptoms of Respiratory Obstruction, if gradual, are:—

Increasingly stertorous breathing, duskiness of the lips, ears and face, increasing to marked cyanosis. If complete, the chest continues to heave without air entering or leaving

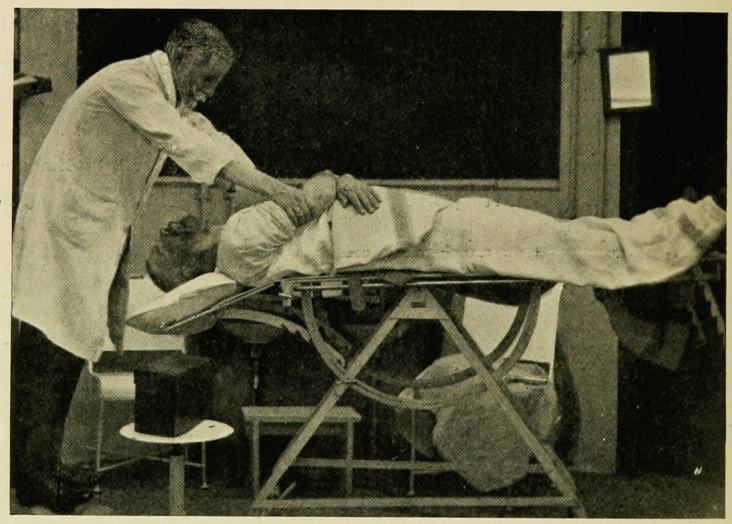


FIG. 38.—ARTIFICIAL RESPIRATION—EXPIRATION (FIRST POSITION).

it, and if the cause of the obstruction be not removed, the patient dies of asphyxia.

Treatment of these Conditions.—As regards treatment, it is convenient to divide patients in the conditions described, clinically, into two classes:—

X. Pale patients, who are suffering mainly from circulatory disturbance.

Y. Cyanosed patients, who are suffering mainly from respiratory obstruction.

X. **The Patient is suffering from Circulatory Disturbance.**—The head should be quickly lowered (children may be completely inverted), the tongue must be drawn out and given to an assistant to keep up the traction while *artificial respiration* is carried out. The movements must not be

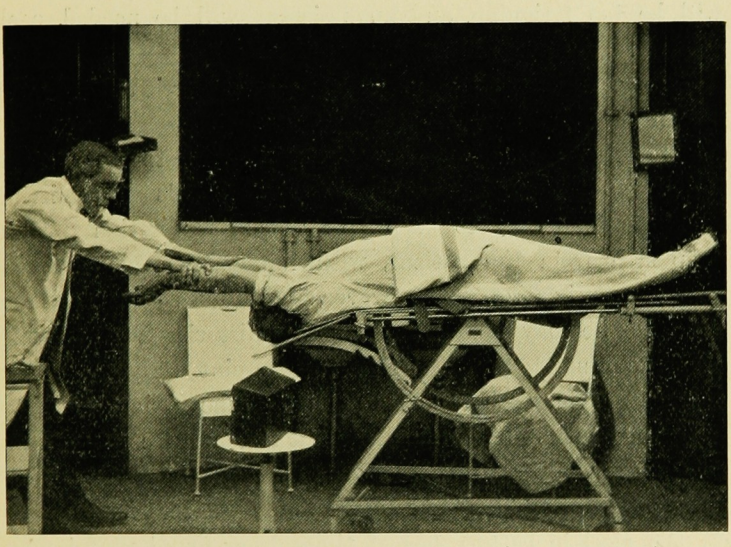


FIG. 39.—ARTIFICIAL RESPIRATION—INSPIRATION (SECOND POSITION).

carried out too rapidly, as is often the case from over-zeal and alarm.

Sylvester's method is the best, and may be briefly described as follows:—

The patient's arms are firmly grasped just above the elbow, and pressed firmly against the thoracic parietes so as to imitate expiration, and then fully extended, and the thorax expanded (so as to imitate inspiration), the extended arms being drawn

upwards and outwards; after counting three, they are brought down again to the side of the chest, the natural rhythm of the respiration being followed as closely as possible. The audible rush of air in and out of the chest will demonstrate that the manœuvre is being properly carried out.

The recovery of the patient will depend on the care with which each movement is performed rather than their frequency. When the patient is slight, one person can carry on the movements unaided, but if the patient is heavily built, the effort will be too fatiguing, and an assistant will be needed, each person taking an arm.

The complete manipulation should be carried out about fifteen times a minute.

No time must be wasted by the anæsthetist or person responsible in applying other remedies; his unremitting attention is needed to keep up artificial respiration until a deep sigh from the patient, with improving colour, heralds returning animation. If, however, there is a second assistant available, he may be employed in administering a hypodermic of strychnine $\frac{1}{10}$ grain, or injecting a pint of hot water or saline solution per rectum. The lips of the patient may also be rubbed with a dry towel, and eight to ten drops of adrenalin solution put into the conjunctival sac. This last is one of the most powerful cardio-vascular stimulants known.

An electric battery has at times been found useful when properly applied, but one is seldom available.

If there be one at hand and in working order, a flat-plate electrode should be placed on the nape of the neck, and a button electrode or wire-brush just between the two heads of the sterno-mastoid. Actual puncture of the heart with a needle has been suggested, but is scarcely justifiable unless the patient is in a desperate condition.

If the abdomen has already been opened for the purposes of the operation, the surgeon may pass his hand in and massage the heart between the diaphragm and the thoracic wall, the

direct mechanical stimulus thus applied being sometimes of service.*

Nitrite of amyl is often advocated, but it will seldom do good, while in most cases it is likely to make matters worse.

V. **The Patient is cyanosed and suffering from Respiratory Obstruction.**—When the breathing stops, the first thing to be done is to open the patient's mouth as quickly as possible by means of a wooden wedge or gag, and pull out the tongue with a forceps. If this does not clear the way, as it frequently will, sweep the finger around the fauces and back of the pharynx to see if any vomited matter or foreign body is lying there. If nothing be found, and if rhythmical tongue traction, combined with chest compression or even full artificial respiration, fails to improve matters, a tracheotomy should be performed, and afterwards artificial respiration kept going for an hour or more unless the patient comes round sooner. As mentioned under the treatment of syncope, the artificial respiration may be supplemented by the injection of strychnine or ether, or a saline enema.

* **Schafer's method of artificial respiration**: While this is for various reasons better suited for the resuscitation of the apparently drowned, it may be of great service in cases in which the patient is very heavy, and the medical man is handicapped for want of assistance. See *Lancet*, Nov. 11, 1905.

CHAPTER IX

THE PREPARATION OF THE PATIENT AND AFTER-TREATMENT

Every patient who is to undergo an operation under an anæsthetic requires a certain amount of preparation for it, varying from a couple of hours' abstinence from food in the case of a short nitrous oxide anæsthesia in a healthy person, to perhaps weeks or months of dieting and medicinal treatment, where a prolonged operation is indicated in those whose constitution generally is in a bad state, or where cardiac and respiratory systems are impaired and halting.

Of course there are many cases of emergency in which immediate operative interference is necessitated, such as dislocation and strangulated herniæ. Here one can only hope the patient's constitution will rise to the occasion. Generally speaking, however, in an operation of any gravity, a few days' dieting and rest in the patient's own house, or in a nursing home in some cases, together with the exhibition of some digitalis, or strophanthus and nux vomica, may have a great bearing on how the patient stands both operation and anæsthetic.

A purgative administered the night prior to the operation is a time-honoured custom. The author is inclined to think, however, that the custom followed by some surgeons of giving perhaps 1 grain of calomel and 3 grains of Pil. Colocynth. et Hyoscy. *two* nights before the operation is distinctly more desirable. It may be followed by 2 oz. of Franz Joseph water, or any saline, on the morning of the day before the operation—or by an enema of soap and water. In the case of feeble patients, ½ oz. liquorice powder to be preferred.

Two or three copious evacuations of the bowels a few hours before a prolonged operation on the abdomen, such as a hysterectomy or gastro-enterostomy, are by no means calculated to put the patient's circulation and nervous system in a condition best fitted to stand the strain of operation, or the chloroform used to produce anæsthesia. By those said evacuations the solar plexus and sympathetic nervous system generally are subjected to a marked depressant influence, and the blood pressure is greatly reduced. Most people are able to recall the sense of collapse and temporary exhaustion occasioned by the free action of a purgative, or following the injection and subsequent evacuation of a large enema. The author is, therefore, strongly disposed to suggest that the purgative should be given thirty-six hours before the operation, and during the day before the operation the patient be most carefully dieted, and fed with such things as are readily digested and leave little residue. It must also be remembered that in some persons a mercurial purgative itself will cause sickness, so that the after-vomiting due to the anæsthetic will in this way be aggravated.

The actual administrations of food on the day of the operation will largely depend on the time at which it is performed. The time of election is undoubtedly 9 A.M., when the vitality of the human species is at about its highest. For this hour, if the patient is awake, a cup of tea or beef-tea might be given at 6 A.M., or 6.30—if not, the rest to body and mind afforded by sleep is more desirable.*

If there be any reason to anticipate after-sickness and acid-intoxication the patient should be put on sodæ bicarbonate, 15 to 20 grs. t.i.d. for several days prior to the operation.

If the operation is postponed until one or two, the patient

* In gastric cases, where there is marked dilatation and food retention, lavage on the evening before or the morning of operation may be desirable. If the case is of a malignant nature, and the patient very feeble, it is best left alone (*v.* F. M. Caird, *Scott. Med. and Surg. J.*, July 1902).

should certainly have a light breakfast at 9 A.M. It is to be borne in mind, however, that nervous fear and apprehension, especially in young people, almost entirely inhibit digestion. The author has seen even bovril, taken several hours before, reappear practically unchanged after the operation. Milk is to be regarded as solid food, and there are few worse things to give just before or after an anæsthetic.

The breakfast should therefore be very light, consisting of weak tea or cocoa, with thin bread or rusks. When chloroform is to be used, if the patient be somewhat collapsed, or have feeble heart action, an ounce of good brandy* in a similar quantity of water may be given twenty minutes before the operation, or a nutrient brandy and beef-tea enema,† or suppository, may be given as an alternative.

The Treatment of a Patient after an Anæsthetic will, of course, depend on the anæsthetic used and the nature of the operation.

After nitrous oxide, most patients are quite ready for food in less even than half an hour. If, however, they happen to be inclined to headache and nauseated, an hour's rest on a couch and a little stimulant will soon put them right. The nausea which one sees occasionally is, generally speaking, due rather to swallowed blood than to the gas.

After ether or chloroform, of course, some vomiting is quite common. It is best to give no food of any kind until this is much subdued, or has disappeared. A few sips of hot water are often grateful to the patient, as also is a little effervescing soda or potass-water—not necessarily for drinking, but to rinse out the mouth. A slice of lemon added to it assists in removing the rather lasting taste of ether. For

* When *ether* is the anæsthetic, in the author's experience a previous dose of alcohol only increases the sickness and stupor after the operation.

† *Enema* (contents)—Brandy, ½ oz.; citrate of caffeine, gr. iij; white of two eggs; water, 3 oz.

the smell of the anæsthetic, due to traces left in the nasal passages, several patients have told the author they found a fresh cake of Vinolia soap—to smell at—invaluable. This is due probably to the "otto of roses" contained.

If the patient has persistent hiccough and retching, a sinapism to the epigastrium will usually control it, and the completely supine position is necessary.

If the vomiting does not subside in an hour or two, 15 grs. sodæ bicarb. in a cup of black coffee sometimes help matters. A fresh cup of tea is peculiarly grateful to patients after ether.

Chloretone given in 15 grs. doses has latterly been used with great success as a preventive of vomiting after anæsthesia. It should be given about fifteen minutes prior to commencement of the operation.

In regard to abdominal operations, particular care is usually taken in restricting the fluid and food taken during the twenty-four hours following the operation.

Sips of hot water, or soda water, or Valentine's beef juice only are allowed in most cases. Whether this is helpful or necessary is difficult to say, but there is no doubt that patients complain most bitterly of a sense of emptiness and sinking, most trying flatulence, and often intense thirst.

Two cases recorded are of interest—No. 1, a girl, æt. 19, emptied a rubber hot-water bottle immediately after an ovariotomy, without any apparent discomfort or harm; and No. 2, a male patient, after a gastrotomy, drank a quart of milk with no ill effect. Such cases make one doubt the desirability of enforcing too strict an abstinence after a laparotomy.

Unquestionably where vomiting is dependent on a condition of acetonæmia, the proper treatment is to flood the tissues as rapidly as possible with alkaline fluid. To this end the patient should be made to drink water in which sodæ bicarb. (about 5 grs. to the oz.) has been dissolved, or have rectal injections—several pints of such a solution. In this way the acid-intoxication is combated.

In almost all cases stimulants are best avoided—unless a small quantity of brandy be given almost neat—in fainting conditions, or in prostration following the operation, while the patient is unconscious, an ounce of brandy and 3 oz. good beef-tea, per rectum.

For headache following ether or chloroform, antikamnia, gr. v., repeated in two hours if needed, is most efficacious.

If vomiting is severe and persistent, nothing will relieve it so much as washing out the stomach.

CHAPTER X

LOCAL ANÆSTHESIA—REGIONAL AND SPINAL

(By W. J. Stuart, F.R.C.S., Assistant-Surgeon, Royal Infirmary, Edinburgh.)

Local Anæsthesia

There are two distinct methods of producing local anæsthesia (or, more correctly, analgesia) generally employed.

I. The local application or injection of drugs.

II. The application of intense cold, usually produced by evaporation.

I. Local Anæsthesia by the Local Application or Injection of Drugs.—*Cocaine hydrochloride* is very commonly used for this purpose. It is a salt of the alkaloid cocaine, $C_{17}H_{21}NO_4$, which was first obtained in 1860 by Gaedeke from the leaves of Erythroxylon Coca. It was first used for surgical purposes in 1884 by Koller of Vienna, and since then has been of priceless value.

Cocaine is soluble in water to only a slight degree, 1 in 700; in 90 per cent. alcohol 1 in 10; freely in $CHCl_3$ and ether, and in many volatile and fixed oils. Cocaine hydrochloride is freely soluble in water, spirit, and glycerine: it is the substance referred to when we speak surgically of "cocaine."

Fungi are apt to grow in the solutions, and, to prevent this, pharmacists usually add boric acid, salicylic acid, or saccharin, when making up aqueous solutions. If solutions of cocaine are kept for some time, or are boiled (at least for more than a few seconds), the cocaine is liable to decompose into inert compounds. Cocaine, in addition to being a local analgesic,

is also to some extent a vaso-constrictor. When applied to the conjunctiva, it causes dilatation of the pupil. Cocaine has been responsible for a number of deaths, but they almost all date back to the time when absurdly large doses were employed, and when the value of the addition of adrenalin was unknown. The more dilute the solution, the larger the quantity of cocaine which can be safely given. With the now invariable addition of adrenalin, 1 grain in ½ per cent. solution or 2 grains in $\frac{1}{10}$th per cent. solution may be regarded as safe.

Toxic Effects of Cocaine.—These may arise if too large a quantity has been employed, or if an otherwise safe dose has been accidentally injected directly into a blood-vessel.

The Toxic Symptoms are:—Trembling of the limbs, especially legs; pallor, a cold, moist skin, feeble, rapid pulse, which in grave cases becomes imperceptible; slow, shallow respirations, headache, vertigo, mental excitement, incoherence of speech, nausea, vomiting, unconsciousness, tremors and other muscular spasms, epileptiform attacks, dilated and unequal pupils, and disturbance of the circulation, ending in a cardiac and respiratory failure.

The Treatment consists mainly in using every effort to stimulate and restore the circulation. The patient, if not already supine, should be instantly placed in this position, air freely admitted, and hot coffee, some alcoholic stimulant, or sal-volatile quickly administered, or strychnine or a drachm of ether injected subcutaneously.

The patient should be warmly covered, and pulse and respiration carefully watched, artificial respiration being used if necessary. There is no direct antidote to cocaine, and nitrite of amyl, once regarded as important, appears to be of doubtful value.

Many of the deaths which have occurred as the result of the use of cocaine have been due to the accidental employment of too strong solutions. An important point in the avoidance of trouble in this respect is to *see that all bottles containing*

solutions of cocaine are very plainly marked with the exact strength, 2 per cent., 4 per cent., 10 per cent., or whatever it may be.

EUCAINE. — This is a synthetic substitute for cocaine. Chemically it is benzoyl-vinyl-diaceton-alkamine. There are two forms, A and B, or α and β: of these the α form is irritating, and "eucaine" in surgery means eucaine β. Two salts are in common use, the hydrochloride and the lactate; the solubility of the former in cold water is about 1 in 30, of the latter about 1 in 3 or 4; either may be employed.

The uses of eucaine and cocaine are identical. The chief differences are:—Eucaine is less toxic than cocaine, and can therefore be used in larger quantities. It is probably not quite so powerful an analgesic, and does not diffuse so readily in the tissues. It is a vaso-dilator instead of a vaso-constrictor, and it causes in the eye no dilatation of the pupil. Solutions of eucaine can be boiled without decomposition, and sterilisation can therefore be assured. Like cocaine, it should be combined with a small quantity of adrenalin; with this addition, about 2 grains in $\frac{1}{2}$ per cent. solution, and 5 or 6 grains in $\frac{1}{10}$th per cent. solution are within the limits of safety. It is preferable to cocaine in any case where a very large quantity of the analgesic solution is required. Both cocaine and eucaine are unsuitable for spinal analgesia.

STOVAINE.—This is the proprietary name of ethyl-dimethyl-aminopropinol hydrochloride,* or hydrochloride of amylene—A B as it is called for the sake of brevity. It is a derivative of tertiary amylic alcohol, and was discovered about 1904 by a Parisian chemist named Fourneau.

The drug crystallises in small bright scales readily soluble

* There appears to be some doubt regarding the chemical formula; the statements of different authorities do not agree with one another on this matter.

in water, methyl alcohol, and acetic ether. It is somewhat less soluble in ethyl alcohol. In reaction stovaine is slightly acid. It is faintly germicidal. Aqueous solutions can be sterilised by moderately prolonged boiling. It appears to be slightly less toxic than cocaine, but also slightly feebler. It also can be combined with adrenalin. There seems to be less tendency to syncope under stovaine than when cocaine is used, partly because it is a vaso-dilator (cocaine being very much the reverse), and also because it has, according to Pouchet, a slightly tonic action on the heart. Except that it can be sterilised by boiling, stovaine appears to have no advantage over cocaine as a local anæsthetic. In spinal analgesia, however, it is largely used.

Tropacocaine.—Derived from Java Coca. The hydrochloride is freely soluble in water. For local anæsthesia it is in no way preferable to cocaine and eucaine, while it appears to neutralise the action of adrenalin. For spinal analgesia, however, it seems to be absolutely the safest and best of the available drugs.

Novocain.—This is a very recent synthetic substance, the hydrochloride of para-amido-benzoyl-diethyl-amino-ethanol. The nitrate may also be employed. A good deal of work has been done with this drug, and it appears quite possible that it may supplant cocaine. In the eye it has no mydriatic action. It is very soluble (1 in 1) in water. It can be boiled again and again without decomposition. Although less powerful than cocaine, its toxicity is very low, and it can therefore be used in larger quantities and stronger solutions. It is very free from irritant action. It is fully compatible with adrenalin. The percentages corresponding to $\frac{1}{2}$ or 1 per cent., and $\frac{1}{10}$th per cent. cocaine are respectively 2 per cent. and $\frac{1}{4}$ per cent., but $\frac{1}{2}$ oz. of the former solution, and 6 oz. of the latter may be injected. For spinal analgesia it seems to be inferior to tropacocaine, but more work may be required to definitely settle the point.

Other new local anæsthetics are alypin (which appears to be efficient), anæsthesine, holocaine, acoine, nirvanin, subcutin, and orthoform.

These anæsthetics may be employed in two ways—

1. By application to a surface.
2. By injection into the tissues.

Application to a Surface.—Application of cocaine solutions to the skin causes no analgesia, but this method is very valuable in eye, ear, nose, and throat cases. For the eye a few drops of a sterilised 2 to 4 per cent. cocaine or 5 per cent. novocain solution are instilled, or a cocaine wafer containing $\frac{1}{50}$th grain may be introduced: the removal of foreign bodies, and such ophthalmic operations as that for cataract may then be painlessly accomplished.

For ear, nose, and throat work the part may be sprayed two or three times with a 4 per cent. solution of cocaine. In the nose and throat the method of painting or swabbing may also be employed, 5 per cent. cocaine being usually sufficient for the nose, but for the larynx 10 or 15 per cent. may be used. Similar solutions of novocain are also suitable. Analgesia is secured in four or five minutes.

Injection into the Tissues.—Here we may make a further sub-division into—

(1) Infiltration anæsthesia, and (2) regional anæsthesia.

(1.) Infiltration Anæsthesia.—By this is meant the induction of local anæsthesia by injection directly into the tissues upon which the operation is to be performed.

Method of Reclus.—In this—the oldest—method Reclus injected $\frac{1}{2}$ per cent. cocaine solutions, not subcutaneously, but into the dermis, producing a strip of œdematised skin. This was incised, and each deeper layer was similarly treated as it was exposed. The method is a tedious one.

Schleich's Method.—Schleich deserves the great credit of being the first to point out that analgesia can be induced with very dilute solutions of the anæsthetic drug. He recommended three solutions:—

	A	B	C
Cocain. Hydrochlor. .	0·2 gramme	0·1 gramme	0·01 gramme
Morphin. Hydrochlor.	0·025 gramme	0·025 gramme	0·025 gramme
Sod. Chlorid. . .	0·2 gramme	0·2 gramme	0·2 gramme
Aq. destil. et steril. .	100 c.cm.	100 c.cm.	100 c.cm.

These solutions are practically equivalent to 2 grains, 1 grain, and $\frac{1}{10}$th grain respectively of cocaine in 1000 minims of water.

Solution B is for ordinary use, A for very sensitive tissues, and C for cases where a large quantity of injection is required. Schleich believed that his solution, which, it will be noticed, is subtonic, that is, of a lower specific gravity than the tissue fluids, produced more satisfactory analgesia than an isotonic solution. He further believed that the morphine diminished the after-pain. Braun modified Schleich's solution by using 0·8 gramme of sodium chloride to 100 c.cm. of water, so as to render the solution isotonic; he also omitted the morphine altogether. The method of anæsthetising by these solutions is to inject very large quantities into the cutis, and then into each succeeding layer of tissue as it is exposed, so that the tissues are rendered *extremely* œdematous. They must swell enormously and be jelly-like on section. Analgesia only exists in the œdematised tissues, and it is produced as soon as the tissues are sufficiently injected. Obviously the recognition of anatomical points is rendered difficult by this method.

Cocaine-Adrenalin Method.—A great advance was made with the discovery of the properties conferred on analgesic solutions by the addition of adrenalin or some other supra-renal derivative. Adrenalin chloride is ordinarily sold in the form of a 1 in 1000 solution, either in sealed ampoules, each containing $\frac{1}{2}$ c.cm., or in bottles containing a larger quantity. Adrenalin acts by constricting the blood-vessels, thus playing

the part of a pharmacological tourniquet, and keeping the cocaine localised for a much longer period. A larger quantity of cocaine can, for some reason, be injected without toxic symptoms when adrenalin is added than without it, possibly because the cocaine is released so slowly into the circulation that it is excreted with sufficient rapidity to prevent poisoning. The advantages, then, of the addition of adrenalin are that the analgesia is prolonged, and that the procedure is rendered safer by the possibility of employing a smaller quantity of cocaine, and by the diminution in the toxic effects of any given quantity injected. The technique is also simplified, for the fluid does not require to be injected endermically, but acts equally well when introduced into the subcutaneous tissue.

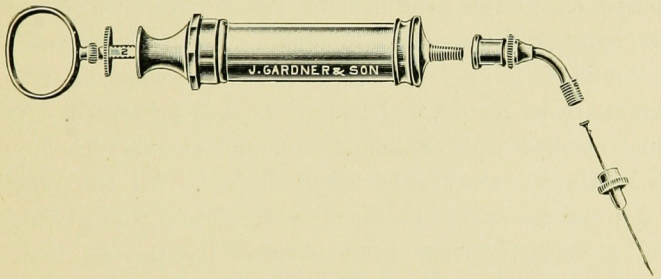


FIG. 40.—ALL-METAL SYRINGE FOR LOCAL ANAESTHESIA.

The choice of syringe and needles is important. The former must be graduated, should be capable of containing about 10 c.cm., and must admit of sterilisation by boiling. Some use an all-glass syringe with glass piston; this from many points of views is very perfect, but the disadvantage is the liability to breakage, especially of the nozzle which fits into the needle. Besides involving expense, this accident may happen when no other syringe is obtainable. An all-metal syringe (Fig. 40) will be found most satisfactory, for, with reasonable care of the syringe, nothing can go out of order. The objection that any faulty working inside is invisible is negligible, for, if a little carbolised vaseline be smeared upon

the piston when the apparatus is put away after use, the contact of plunger with cylinder will always be so perfect that no fear need be entertained that any of the injection fluid will escape backwards past the piston. A small intermediate metal mount screws on to the syringe; this can be unscrewed from the syringe without disturbing the needle when the syringe requires refilling. It is curved so that the needle is set at an obtuse angle to the syringe, which greatly facilitates the injection. Perhaps the most convenient needles are Schimmel's, which are sold sterilised, in small tubes, each tube containing six needles. Each needle has a small flattened head, about the size of the head of a common pin: the needle is pushed through the hole in a small mount from behind, which is then screwed on to the intermediate metal piece just described. The greater the force used in making the injection, the more forcibly is the head of the needle pressed forwards against the aperture in its mount, and leakage is thus prevented. As the actual needles, which all fit the mount, are very cheap, each can be thrown away after use if desired. All the junctions in the syringe apparatus must be absolutely water-tight.

The needle, syringe, glass measure for the solution, and everything which is to come into contact with the anæsthetic solution must be boiled in plain water. Soda, lysol, carbolic acid, &c., all destroy the analgesic action of the drug.

If cocaine be the drug employed, a solution of about $\frac{1}{10}$th per cent. is sufficiently strong, *e.g.*:—

Cocain. Hydrochlorid. . .	1 grain.
Adrenalin Chlorid. (1 in 1000) .	4 to 7 minims.
Sol. Sod. Chlorid. (0·75 per cent.)	2 ounces.

Double this quantity may be used if necessary, but is seldom required. As neither adrenalin nor cocaine solutions can be safely boiled, the solution is perhaps best made up freshly on each occasion. Into a boiled graduated wide-mouthed glass measure are poured 2 ounces of normal saline solution. (Salt

tablets for the preparation of normal saline solution may be purchased.) To this is added a 1 grain tablet of cocaine, and 5 or 6 minims of adrenalin solution are poured out of the bottle after carefully cleansing its mouth. An even safer method is to employ sealed glass ampoules of adrenalin solution, each of which contains $\frac{1}{2}$ c.cm., *i.e.* between 7 and 8 drops. This mixture gives very satisfactory results.

If eucaine be preferred, it is better to use a stronger solution, about half the above-mentioned quantity of normal saline solution being used for each grain of eucaine.

Good as are the results with cocaine, it seems possible that equally good results may be obtainable with considerably less trouble by means of $\frac{1}{4}$ per cent. novocain. A stock solution of 2 per cent. novocain (the strength for regional anæsthesia) is kept, and is boiled before use, as it can be repeatedly boiled without losing its effect, and then a portion is diluted; or the amount required can be first added to normal saline solution and that mixture boiled. Adrenalin is then added. It may be mentioned that a synthetic product has recently been produced, which claims to be identical with adrenalin, and capable of being boiled at least once without decomposition. If it justifies its claims, it will prove a valuable addition to our list of drugs, as it will be boiled along with the novocain.

The needle is introduced into the subcutaneous tissue, and pushed on slowly to its full length, the fluid being injected as it advances. The needle is then partially withdrawn, and pushed similarly in other directions, so as to infiltrate an area beyond what will probably be required. If there are important vessels near, the deeper tissues must be infiltrated as they are exposed. In the absence of such vessels, the infiltration of the deeper tissues may be carried out through the skin. The skin blanches within two or three minutes of the injection, and analgesia is complete in about ten minutes or less in the case of cocaine, but in the case of eucaine fully double that time is required. The duration of the analgesia is at least an hour and a half,

often considerably more. So far as possible only clean cutting should be employed during the operation: blunt dissection pulls upon unanæsthetised tissues beyond the zone of infiltration.

When anæsthesia in inflamed tissues is desired, the infiltration should be begun outside the area of inflammation, and then gradually carried into it.

Owing to the vaso-constrictor action of adrenalin, there is unusually little bleeding during the operation, but there is rather more tendency to reactionary bleeding. Hence special care should be taken at the operation to tie all bleeding points.

The infiltration, if carefully performed, has practically no bad effect on the healing of the wound. A few instances of sloughing of the skin have been recorded, but are probably due to faulty solutions or to infection of the wound.

There would appear to be no doubt that some patients have more after-pain after an operation under local than under general anæsthesia. It may be argued that the dulling effect of general narcosis is absent, and that the pain is therefore more noticed. It appears, however, to be the opinion of most observers that there is in some cases after-pain due to the drug, but, if it occurs, it has practically always passed off by the morning of the day following the operation, and is rarely so severe as to require morphine.

To enumerate all the operations which can be or have been performed under local infiltration anæsthesia would take up too much space. It is extremely useful in many conditions in which general anæsthesia is dangerous; for example, in operations for empyema and goitre, and in cases where the patient is collapsed or feeble, as often happens in strangulated hernia, colostomy, gastrostomy, &c. There are numerous other operations in which the patient may be saved the inconvenience of a general anæsthetic, as, for example, tracheotomy, skin-grafting, excision of varicose veins, simple mammary tumours, wens and other skin growths. Infiltration anæsthesia is not, however, suitable for cases, such as in the removal of deeply-

seated malignant and other tumours, where the extent of the dissection is uncertain, and likely to be extensive.

(2.) Regional Anæsthesia.—The result of injecting cocaine into a nerve or into the immediately surrounding tissue is to absolutely block all conduction at that point, a condition of sensory and motor paralysis being produced in the distribution of the nerve below the injection which is equivalent to a temporary physiological section of the nerve. In this way Crile, by exposing the main nerve trunks under infiltration analgesia, has cocainised them, and painlessly performed such operations as amputation at the shoulder joint. Moreover, the block on the nerve completely prevents the passage up it of the impulses which cause shock, which still pass during general anæsthesia. Braun found that he could, by pushing his needle through the skin and injecting a cocaine-adrenal solution round an accessible nerve, cause in about ten minutes sensory paralysis of two hours' duration or longer in the area supplied by the nerve. This perineural injection is more convenient in many places than an endoneural injection after exposing the nerve. The strength of solution required is $\frac{1}{2}$ to 1 per cent. cocaine or 2 per cent. novocain, with 3 or 4 drops of adrenalin in every $\frac{1}{2}$ ounce. Oberst was the first to employ this method; he cocainised the digital nerves, localising the drug by means of a proximal tourniquet. By perineural injections all conditions distal to the web of the fingers and toes can be dealt with, such as whitlow, ingrowing toe-nail, hammer toe, and subungual exostosis. The median nerve at the wrist, the ulnar at wrist or elbow, the external popliteal at the knee, and the anterior and posterior tibials at the ankle are all amenable to this treatment. Nerves with a long subcutaneous course—for example, the radial in the forearm and the musculo-cutaneous in the leg—are best reached by infiltrating the subcutaneous tissue across their course with a $\frac{1}{5}$th per cent. cocaine solution with a few drops of adrenalin. The application of a rubber band above the injection hastens the onset of analgesia.

There is no doubt that local analgesia, whether of the infiltration or of the regional variety, is, with our present experience and knowledge of the drugs, practically unattended by danger. To the country practitioner, who must work alone, it is invaluable. Whatever may be the propriety of employing *spinal* analgesia, there is no doubt that in all cases where *local* anæsthesia will meet the requirements of the case, it is the method which the surgeon is bound to recommend.

II. Local Anæsthesia by Freezing.—Originally the necessary reduction of temperature was obtained by the application of a rubber bag containing salt and crushed ice. It was difficult to restrict the freezing to the desired area, and sloughing sometimes followed.

The ether spray introduced by Sir B. W. Richardson was a distinct advance. With a rubber ball pump and a nozzled bottle methylated ether is played in a fine spray over the part, which is frozen in about two minutes.

The method most popular at the present day is freezing by means of the ethyl chloride spray, which is both rapid and convenient. The glass cylinder in which the drug is contained is exactly the same as that for general anæsthesia (Fig. 8) except that the outlet is extremely small. Pressure upon a stop-cock near the neck of the cylinder causes a fine jet of the fluid to spurt out under the influence of the heat of the hand which holds the little apparatus. The cylinder should be held as far from the patient's skin as is possible without misdirecting the jet, eight or ten inches being the minimum, so that the jet has time to break up into a fine spray. As the skin freezes, it becomes hard and intensely white in round patches which coalesce. Freezing is hastened by blowing on the skin while the spray falls upon it.

The method is very imperfect. Sloughing occasionally occurs. The analgesia is to be measured not by minutes but by seconds, and is not very perfect. The frozen tissues are

hard and difficult to cut, and their appearance is much altered. The process of freezing itself causes pain, and there is generally pain as the part thaws. It is quite common for a patient who has had a small incision made under this form of local anæsthesia, and who requires a repetition of it, to ask that the little operation shall rather be done without any such pretence of anæsthesia.

Freezing anæsthesia is only suitable for the opening of superficial abscesses and similar small operations, and even in such cases infiltration or regional analgesia, if possible, is far superior. This is especially true of the opening of whitlows. In dental extractions it is said to be almost equally useless, anæsthesia as a rule, if present, being largely due to the patient *inhaling* a certain amount of the ethyl chloride vapour.

Spinal Anæsthesia.

By this is meant the abolition of pain sensation in the lower extremities and a varying amount of the lower part of the trunk by the injection of some drug by lumbar puncture into the spinal subarachnoid space, consciousness meanwhile being preserved. The word "analgesia" is a more accurate term than "anæsthesia," as tactile sensibility is by no means always abolished. It is really a form of regional analgesia in a situation where a large number of nerve roots are at the same time exposed to the influence of the anæsthetic. The method is a recent one, practically not dating back beyond the last year or two of the nineteenth century, and there is very little in connection with it which can be regarded as definitely established and universally accepted. As the space in this chapter is necessarily limited, theories and hypotheses cannot be discussed, nor can the variations in technique be described, but an attempt will be made to state briefly under various headings the chief points of this method of analgesia.

Choice of Drug.—Many drugs have been proved by experiment on animals or in man to be unsuitable; for example, eucaine-α, acoine, holocaine, anæsthesine, nirvanin, morphine, antipyrin, &c. The only substances which we need seriously consider are cocaine, eucaine-β, stovaine, tropacocaine, novocain, and alypin. *Cocaine*, the drug originally used by Bier, the pioneer in spinal analgesia, proved dangerous. The addition of adrenal preparations, which have proved so valuable in local analgesia, undoubtedly diminished this danger; but, even with this safeguard, cocaine is so unsafe that it has been universally discarded. *Eucaine-β*, though less toxic, possesses no special advantages. *Stovaine*, first used as a spinal injection by Chaput, gave greatly improved results, and is the drug most frequently used in France, besides being used by many surgeons elsewhere. Its relative safety is attributed to the fact that it exercises rather a tonic influence on the heart, and dilates instead of contracting the blood-vessels. It acts more strongly, however, upon the motor functions than does perhaps any other of the spinal anæsthetics, and the resulting paralyses, even if only temporary, may be extremely awkward if the muscles of respiration are affected. *Tropacocaine* is gaining rapidly in favour at the expense of stovaine, and reports and statistics suggest that it is the best drug at present known for spinal analgesia. Its action is more exclusively than stovaine exerted upon the sensory fibres, and respiratory and other muscular paralyses are therefore less frequent: unpleasant by-effects and after-phenomena seem to be also less troublesome. *Novocain* is so recent a substance that a fair judgment upon its merits can hardly yet be expressed. It is very stable and can be boiled again and again, but, in comparison with tropacocaine, appears to be open to the same objections as stovaine. Regarding *Alypin* the literature is very scanty. It has, however, already been fatal in more than one case. The addition of adrenalin to any of the anæsthetics now in use seems, for spinal injection, to be rather injurious than useful.

Dosage.—An average dose of tropacocaine or stovaine is 0·05 gramme (*i.e.* 5 centigrammes, or a little over ¾ grain). As little as 0·03 gramme may be sufficient for an operation in the region of the anus, while 0·06 or 0·07 may be employed where a high analgesia is required. Novocain may be used in the same or in rather larger doses. As a solvent, salt solution is generally employed, the percentage of salt being such that the resulting mixture is isotonic. A 5 per cent. solution of the drug is a convenient strength, 1 c.cm. then representing the ordinary dose. Many observers believe that the larger the quantity of fluid injected, the amount of anæsthetic contained remaining the same, the higher will the analgesia extend. As such large additions to the contents of the subarachnoid space might raise the pressure to a dangerous extent, they recommend that 3-10 c.cm. of cerebro-spinal fluid should be drawn back into the syringe, and, after there mingling with the anæsthetising solution, be at once re-injected. This view is held by Dönitz, who, as Bier's assistant, has had probably unequalled opportunities of studying spinal analgesia. The absolute sterility of the solution is, of course, essential, and must be secured without decomposition of the anæsthetic. Novocain can be boiled; so, though to a less extent, can stovaine. Less stable drugs must be dealt with by fractional sterilisation. It is convenient to purchase the drug in ampoules which have been put on the market by the large manufacturing chemists, each ampoule containing one carefully sterilised injection. Some prefer to place in the syringe the desired quantity of the substance in tablet form, withdraw cerebro-spinal fluid in which the tablet dissolves, and then re-inject. The sterility of the tablets must be above suspicion.

Technique of Injection.—The spinal cord terminates opposite the body of the 1st or the upper border of the 2nd lumbar vertebra. The subarachnoid space extends down to the 2nd or 3rd sacral vertebra, and contains in its lower part chiefly

the cauda equina. Between the two halves, into which the cauda equina resolves itself, is a mesial space, called by Dönitz the cysterna terminalis, which, in addition to cerebro-spinal fluid, contains the conus medullaris and the filum terminale. It is into this space that we wish to make the injection, for, should the needle pass among the nerves of the cauda equina, the anæsthetic solution is apt to become entangled, and inadequate, unilateral, or other imperfect effects are produced. The interval between the 3rd and 4th lumbar spines is usually chosen for the lumbar puncture, but some inject one or even two interspaces higher. Formerly the needle was inserted between the laminæ about 1 cm. from the middle line, but now, for the reason just stated, the mesial puncture is preferred. The needle or cannula should be 8-12 cm. (about 4 inches) in length, and about 1 mm. in cross section. It is an advantage if it is made of some substance which does not easily rust, such as hard nickel. The point should be sharp, but hollowed out, so that it is practically certain, if cerebro-spinal fluid escapes, that the whole of the aperture is inside. The use of a long sloping point, like an ordinary hypodermic needle, may result in the aperture being partly inside and partly outside the arachnoid sac; cerebro-spinal

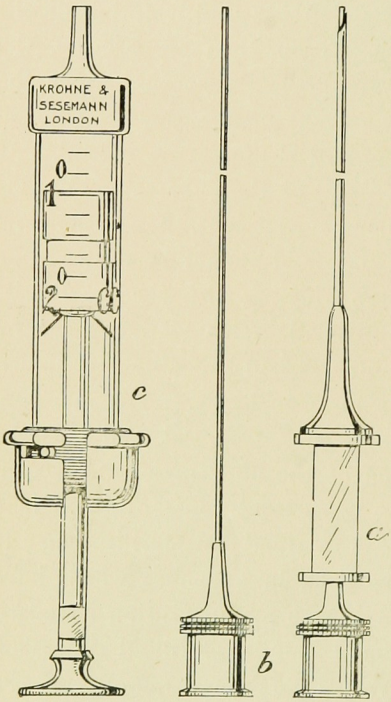


FIG. 41.—BARKER'S SYRINGE, CANNULA AND NEEDLE FOR SPINAL ANALGESIA.

fluid may then escape freely, but the injected anæsthetic solution may be to a large extent discharged outside the sac. The needle possesses a stylet which exactly fits it, and corresponds in shape to it. The needle must be very sharp; otherwise, if the walls of the sac are lax, it is quite possible to push the posterior wall in front of the needle until it comes in contact with the anterior. The syringe must accurately fit the cannula, must be graduated, and capable of being boiled. The "Record" syringe fulfils all requirements. It must contain at least 2 c.cm., and, if cerebro-spinal fluid is to be drawn back into it to mix with the anæsthetic, should have a capacity of 10 c.cm. The whole injection apparatus must be be boiled in pure water; any trace of soda decomposes the anæsthetic and is very irritating. If possible, a special little sterilising tin should be kept for the purpose, and the needle and syringe should never be put to any other use.

The patient's back must be fully flexed. The patient is usually in the sitting position on the table, and leans forward as far as he can. A surgeon may sometimes prefer that he should lie on one side, with knees drawn up and shoulders forward. The skin of the back is rigorously sterilised as for an operation, every trace of antiseptic being finally washed off. The neck of the ampoule containing the drug is broken, the syringe is charged through the cannula, and is laid aside on a sterile towel. The surgeon feels through a sterilised towel the highest point of each iliac crest; the line joining these two points crosses the fourth lumbar spine. The needle with stylet is pushed through the skin opposite the selected interspace, usually that between the 3rd and 4th lumbar spines. It is not essential to freeze the skin with ethyl chloride before the puncture is made, though this may be done. The needle is made to travel forwards and very slightly upwards. When it meets the intervertebral ligament, some force is required. When the ligament is passed, the stylet is removed, unless it has been previously removed immediately after having traversed

the skin, and the needle is pushed on. A sudden movement forward of the needle, accompanied often by momentary pricking pain, indicates that the point has entered the sub-arachnoid space, and clear cerebro-spinal fluid should escape in rapid drops, or in a small stream. Till such flow occurs, the injection must on no account be made. If the flow is

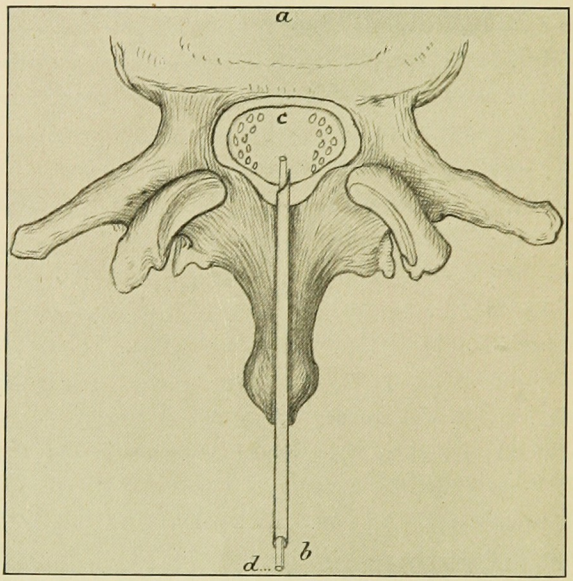


FIG. 42.—DIAGRAM, ADAPTED FROM "QUAIN'S ANATOMY."

Shows third lumbar vertebra from above in part; *a*, part of body; *b*, hollow needle with open point half-way through the dura; *c*, dural tube in section with nerves of *cauda equina* on either side in section; *d*, cannula entering the canal completely through hollow needle.

unsatisfactory, the needle may be moved slightly; and if this does not produce the desired flow, or if the fluid is blood-stained, a fresh puncture is made in the space above or below. When a satisfactory flow is obtained, the syringe with the proper amount of the drug is picked up, and, all air having been carefully expelled, is fitted on to the base of the needle

or cannula; 3 to 10 c.cm. of cerebro-spinal fluid are withdrawn into the syringe, and the whole is re-injected. Some repeat the filling and emptying of the syringe several times; some, on the other hand, inject the anæsthetic without *any* withdrawal of cerebro-spinal fluid. Barker employs a second cannula with a transverse terminal aperture, which passes inside the first, and prevents the possibility of any of the injection not reaching the sac (Figs. 41 and 42). Syringe and cannula are withdrawn together, the puncture is sealed with collodion, the patient lies down, and the cleansing of the actual operation area is begun.

All operators have occasionally failed to reach the sac. These failures, however, become very infrequent with increased practice.

Course and Duration of Analgesia.—The sequence of the phenomena varies slightly, but the following is the usual order. Numbness with diminution and loss of sensibility to pain in scrotum, rectum, back and inner side of thigh, disappearance of knee jerk. Then loss of Achilles reflex, and of pain sensation on back of leg, then sole, then front of lower extremity; also of skin reflexes. Next, loss or diminution of sensibility to pain in inguinal and hypogastric regions. The analgesia extends up pretty constantly to the umbilicus; above, it is more uncertain. The order of disappearance of the various sensations is—pain, temperature, touch, pressure. Paresis or paralysis comes later than analgesia. The effects disappear more or less in the reverse order.

The average duration of analgesia is three quarters to one and a half hours—with novocain rather longer.

Methods of Increasing the Height of the Analgesic Area.—Bier and Dönitz believe that this is accomplished by inducing a movement of the cerebro-spinal fluid towards the head. They either (1) raise the pelvis; or (2) increase the

quantity of fluid injected with the anæsthetic; or (3) put an elastic bandage round the neck before the injection, thus congesting the brain, and remove it after injection, thus diminishing the quantity of intra-cranial blood, and causing a consequent compensatory movement upwards of anæsthetic-laden cerebro-spinal fluid. Barker believes that the best method is to use an injection fluid heavier than cerebro-spinal fluid (stovaine 5 per cent., glucose 5 per cent., in water); inject with the patient on his side, with pelvis and shoulders raised, and then roll him on to his back, so that the heavy anæsthetic fluid gravitates to the mid-dorsal region. The number of cases thus treated is still too small to allow of a definite opinion upon it.

Complications.—These are now becoming much less frequent and less severe, owing to improvement in technique and the more extensive use of tropacocaine.

As *immediate complications*, there have been observed nausea, palpitation, retching, vomiting, collapse, difficulty or (with stovaine) paralysis of respiration, severe general shivering, incontinence of urine and fæces, death on the table.

As *later complications* may occur headache, stiffness of neck, pain in back, vomiting, retention of urine, incontinence of urine and fæces, rise of temperature, paralysis of lower extremities or of eye muscles, especially the external rectus. Aseptic non-fatal meningitis is also reported, and septic meningitis, from faulty aseptic precautions, is a remote possibility. Deaths have also occurred, most of them, however, hardly due to the anæsthetic procedure.

Indications.—Spinal analgesia may be regarded as indicated in old, broken-down patients (who bear it very well); in cases of bronchitis, emphysema, and non-tuberculous lung conditions; in certain heart cases; in diabetes (probably). It appears to distinctly lessen shock in severe cases, such as peritonitis. It

may also be valuable for drunkards, in order to avoid the strain of struggling; for the reposition of fractures and dislocations, which require deep narcosis; for examination of and operations on the rectum, as the sphincters are generally relaxed; and in cases where adequate assistance for general anæsthesia cannot be obtained.

Contra-Indications.—Youth up to the age of 12 or 15 years; diseases of brain or spinal cord; septic processes elsewhere (lest a metastatic meningitis may arise); mental diseases; extreme nervousness or excitement; inflammatory conditions in the lumbar region, rendering aseptic puncture doubtful; and all cases where local anæsthesia is feasible. Caution should be exercised in cases of tuberculosis or recent syphilis (lest the spinal trauma prove a starting-point for a new focus of the disease; in kidney disease (possibly); and in advanced arteriosclerosis. Above the level of the umbilicus one cannot count with anything like certainty upon satisfactory analgesia.

Conclusions.—It is sometimes asserted that the consciousness of the patient is extremely unpleasant to himself and disturbing to the surgeon. For such patients and surgeons spinal analgesia is unsuitable. Most patients, however, we believe, dread greatly the surrender of consciousness involved in narcosis, and welcome any means of escaping it. The main question turns on the relative safety of general anæsthesia and spinal analgesia. Strauss has collected 22,717 cases of the latter, and even including cocaine, the mortality fairly attributable to the method or to mistakes connected with it is 1 in 2524. Probably, with more extensive use of tropacocaine and increasing practice, these figures will be improved. At present the position of affairs may be not unfairly stated thus: Spinal analgesia is not a procedure devoid of danger. Its mortality hitherto is probably greater than that of general anæsthesia when the latter is in skilled or moderately skilled hands. There

are a number of cases in which general anæsthesia is contra-indicated or spinal analgesia is indicated. Where no such contra-indication or indication exists, it is probably at present the duty of the surgeon, except when the patient expresses a contrary desire, to employ general anæsthesia.

CHAPTER XI

ANÆSTHETIC COMMISSIONS AND INVESTIGATIONS

The Committee of the Royal Medico-Chirurgical Society (London) was appointed in 1864 "to inquire into the uses and the physiological, therapeutical, and toxical effect of chloroform, as well as into the best mode of administering it, and obviating any ill consequences resulting from its administration." Among the members were such men as Mr. Thomas Bryant, the late Dr. George Harley, Prescott Hewitt, Sir James Paget, Sir William Priestly, and Richard Quain. Mr. Clover administered the chloroform for the experiments, and devised much ingenious apparatus for carrying them on. The Committee collected a great many facts, and made valuable suggestions for the guidance of anæsthetists. Their Report, completed on the 14th June 1864, occupied over one hundred pages of their transactions, and some of the rules relating to the administration of chloroform were sound and valuable, and will bear repeating at the present day.

Others were erroneous, and have been shown to be so by more extensive clinical experience and reliable physiological research.

First British Medical Association Committee.

In 1880 a Committee was appointed by the British Medical Association to discuss and generally investigate the relative safety of anæsthetics and make a report on them. Many cases, collected by them, of death during the administration of anæsthetics were clearly proved to be due either to careless-

ness or ignorance, and in some cases both. The Report appeared in the *British Medical Journal* for 15th December 1880, and its practical outcome was a strong condemnation of chloroform, a partial condemnation of ether, and a strong recommendation of dichloride of ethidene — an anæsthetic which to-day is practically unknown to the profession, and which has entirely fallen into disuse from its high price and want of any special advantage over chloroform or ether.

The Hyderabad Commissions.

In 1889, on the recommendation of Surgeon-Major Lawrie, the Nizam of Hyderabad generously put aside a sum of money to defray the expenses of a special Commission of Scientists on Anæsthetics. The Commission consisted of Dr. Athir, Mr. Kelly, and Mr. Chamarette. They particularly directed their experiments to the solving of the question as to whether chloroform ever affected the heart directly or not. To obtain evidence on this point they killed with chloroform upwards of 120 full-grown dogs, averaging over 20 lbs. weight each. In addition to this they performed many hundreds of experiments, and tested the value of artificial respiration in nearly every case by reviving the dogs over and over again after the breathing had stopped, and before the heart had ceased to beat. They reported accordingly. The profession, however, hesitated to accept their conclusions, and it was accordingly proposed to hold a second Commission at Hyderabad, and to carry out further extensive physiological experiments. The Nizam again rose to the occasion with the necessary funds, and Dr. Lauder Brunton was sent out from England by the *Lancet* to assist. The former conclusions of the Commission were corroborated in most respects, but it was soon shown by more eminent and expert physiologists, notably Drs. Shore, Gaskell, and Leonard Hill, that there were numerous fallacies in the technical work of the Commission, and that the con-

clusions which they based on many of their tracings were erroneous. Beyond stimulating scientific research in the physiological laboratory in the department of anæsthetics, the Hyderabad Commission cannot be said to have benefited humanity to any extent. The researches of the anæsthetists appointed by the *Lancet*, particularly Dr. Dudley Buxton, into the evidence afforded clinically by over six hundred authentic cases of death under chloroform, &c., were of considerable value. Dr. Dudley Buxton made the following deductions from the reports as a whole:—

1. That the death-rate under anæsthetics heretofore has been unduly high, and may, by improved methods and greater care, be lowered.

2. That ether, when properly given from an inhaler permitting graduation of the strength of the vapour, is the safest anæsthetic in temperate climes for general surgery.

3. That nitrous oxide gas should be employed for minor surgery, and should replace chloroform in dental surgery.

4. That chloroform, when given by a carefully trained person, is a comparatively safe body, but is not in any case wholly devoid of risk.

5. That no age or nation is free from danger under anæsthetics.

6. That the perils of anæsthetics, however slight, demand that the undivided attention of a duly qualified and trained medical man should be given to the administration of the anæsthetic.

The Second British Medical Association Committee

was formed at the Bournemouth meeting of the Association, 1891, to investigate the clinical evidence with regard to the effect of anæsthetics upon the human subject, and especially the relative safety of various anæsthetics; the best methods of administering them, and the best methods of restoring a patient in case of threatened death. All anæsthetists through-

out the kingdom were requested to record their cases during the year 1892 in books prepared for the purpose. Accordingly, in January 1893, 156 books were returned with details of 26,000 cases in hospital and private practice. These were very carefully investigated and classified by a Sub-Committee, which met over three hundred times and expended an enormous amount of labour on the matter. They divided the cases into—

(*a*) Complicated, and (*b*) uncomplicated.

The complicated were divided into cases of—

1. Anxiety.
2. Cases of danger.
3. Fatal cases.

Of the latter twenty-nine were recorded. Eighteen of the fatalities occurred under chloroform; three of these were considered entirely due to the anæsthetic, and four to the anæsthetic principally and to the patient's condition secondarily. In the others there was either doubt as to the relative shares taken by the three factors—anæsthetic, patient's condition, and operation; or the death was distinctly due more to one or both of the two latter causes than to the anæsthetic.

Of the deaths during ether anæsthesia, not one was held to be due entirely to the anæsthetic. Six occurred under ether and one under gas and ether. There is a strong probability that the fatal results were reflexly produced by the operation; in other cases by entrance of vomitus into the larynx.

Chloroform was found to put the patient's life in jeopardy once in two hundred administrations, ether once in fifteen hundred; and these figures are sufficiently striking to make those who advocate the universal and exclusive employment of chloroform pause and consider their position. Severe and prolonged vomiting was found to be more common after chloroform than ether, although transient retching occurred more frequently after ether.

Among the most important conclusions of the Committee were the following:—

I. No method of administration of chloroform is free from danger, but an examination of the complicated cases appears to show that the occurrence of danger depends largely upon the administrator who employs any particular method.

II. Complications and danger are more commonly met with in males than females.

III. Excluding infancy, the complications and dangers of anæsthesia increase *pari passu* with advancing age.

IV. Danger to life is especially likely to be incurred in early periods of the administration of the anæsthetic and during light anæsthesia.

V. Chloroform is about twice as dangerous in males as in females. Most dangerous during early infancy and after thirty years of age.

VI. In good health chloroform is very much more dangerous than other anæsthetics. In grave conditions chloroform still remains the least safe anæsthetic, but the disparity between it and other anæsthetics is far less marked than in health. When danger does occur under chloroform, in the large proportion of cases the symptoms are those of primary circulatory failure.

VII. Vomiting during anæsthesia which may lead to danger seems to be much more frequent under chloroform than other anæsthetics. Struggling is a great source of danger. Further, circulatory depression following anæsthesia is more commonly seen after chloroform.

Conclusions in Regard to Ether.—1. Ether, where employed throughout, or preceded by ethyl chloride, nitrous oxide gas, or by CE, is singularly free from danger in healthy patients.

2. Minor troubles in administration due to laryngeal irritation and increased secretion are more common under ether than under chloroform and its mixtures.

3. Bronchitis is more common after ether than after chloroform, especially in hospital practice, but neither chloroform nor local anæsthesia is free from some risk of bronchitis as an after-effect or sequela.*

The general and final conclusion of the Sub-Committee was that they were convinced that by far *the most important factor in the safe administration of anæsthetics was the experience acquired by the administrator.* Accordingly, no one should be allowed to qualify until he or she has obtained some experience and shown some proficiency in this important branch of medical work.

The Third British Medical Association Committee

consists of a small Special Committee appointed in 1901 at the instigation of Professor Waller. It consists of Sir Victor Horsley, Professor Dunstan, Dr. Dudley Buxton, Sir James Barr, Dr. W. J. M'Cardie, Professors Sherrington, Martin, Brodie, and Dr. George Rowell. The services of Mr. Vernon Harcourt were also engaged, and a yearly report has been published of the work carried out by the Committee.

The Committee critically reviewed the methods of determining chloroform quantitatively in the atmosphere. Of the two classes of method, *gravimetric* and *chemical*, they preferred the latter as being the more likely to give accurate results.

The object of the Committee was to put the determination of chloroform quantitatively on a sound basis. Having attained this, they proceeded to discover, by means of it, two practical points.

(1.) The smallest possible dose by volume in the atmosphere breathed requisite to induce anæsthesia. (2.) The smallest possible dose to maintain analgesia, after the initial loss of consciousness. It was shown that although it was the common practice to begin with a considerable quantity of

* Confirmed by v. Mikulicz, of Breslau. *Trans. Germ. Surg. Soc.*, 1901.

chloroform and then reduce the dose, it was not recognised to what a remarkable degree this could be carried out. To demonstrate this, Mr. Vernon Harcourt devised a special apparatus, and by means of it in certain cases chloroform anæsthesia was obtained with what might almost be described as mathematical precision. It was found that to obtain complete unconsciousness to the pain of the incision, &c., the dose to be adequate was from 1 to 2 per cent. of the atmosphere breathed. For the maintenance of anæsthesia the dose could be diminished to even ·2 per cent.

The Committee have as yet been unable to decide whether chloroform accumulates in the body or not, but Professor Sherrington established the fact that it does not accumulate in the heart itself at anyrate.

The investigations of the Committee are not yet completed, but a report is to be issued shortly.

APPENDIX A

REGULATING CHLOROFORM INHALERS

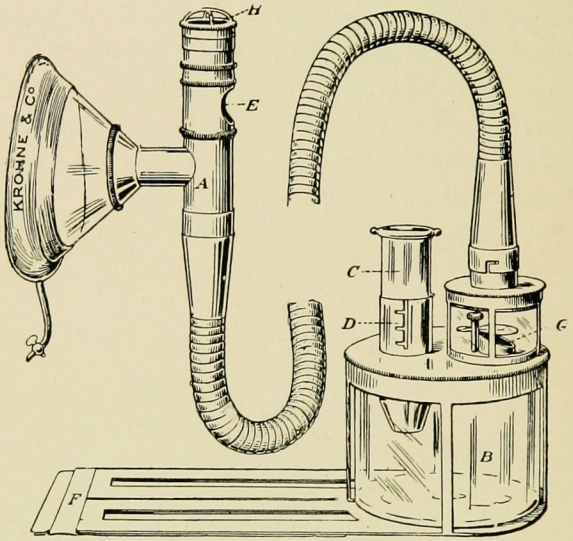


FIG. 43.—HARVEY HILLIARD'S REGULATING CHLOROFORM INHALER.

HARVEY HILLIARD'S REGULATING CHLOROFORM INHALER.—This is the most practical apparatus of this nature on the market at the present time. The designer claims that it is capable of giving a sufficient dose to any kind of case under any ordinary surgical conditions, and being made with wide airways, it offers no obstruction to the patient's respiration at any time.

All percentages from zero up to a maximum of 4·5 per cent. are available.

DIRECTIONS FOR USE.

Connect the facepiece and stopcock (A) with the glass reservoir (B) by means of the flexible aluminium tube, as in the illustration.

Place one ounce of chloroform in the reservoir, and fix it in its stand (F). The base of the stand must be fully extended and pushed beneath the patient's shoulder, under his pillow, where it will remain perfectly steady.

Place the "regulating tube" (C) in its highest position in the notched air inlet tube (D), as in the illustration. (G) is the balanced inspiratory valve, and (H) the expiratory valve. The quantity of chloroform vapour absorbed by inspired air will then be 3 per cent., supposing the "accessory air inlet" to be quite closed, whilst in the lowest position it will be 4·5 per cent. Intermediate positions will give the intermediate percentages.

Now open the "accessory air inlet" (E) in the stopcock to its fullest extent, so that the breathing may be through it and not over the chloroform and through the rest of the apparatus. Accurately fit the facepiece on the patient's face, and direct him to breathe quietly and naturally. Meanwhile gradually close the accessory air inlet, thus making an increasing greater proportion of the inspired air pass over the surface of the chloroform. If this be done steadily and gradually, the patient will be unaware of, and will not resent the resulting increase of chloroform inspired. When once the accessory air inlet is closed, the strength of chloroform vapour may be quickly further increased for a few minutes, and the maximum strength given (4·5 per cent.) by pushing the "regulating tube" down as far as it will go. In this way the second stage will be rapidly passed through, and the whole induction will then take about six minutes. The closest watch must be kept upon the patient whilst this high percentage (4·5 per cent.) of vapour is being administered, and as soon as the corneal reflex disappears the percentage must be immediately reduced. When once full anæsthesia has been established, a patient will usually remain sufficiently anæsthetised with the "regulating tube" removed altogether, thus reducing the percentage of chloroform vapour to not more than 1·5 per cent. If a further reduction of dose be indicated, the accessory air inlet may be opened. If the anæsthetist desire to administer some percentage of vapour between 1·5 per cent. (as when the regulating tube is out) and 3 per cent. (when it rests in its highest position), he may do so by maintaining it in this latter position, and opening the accessory air inlet in the stopcock as much or as little as the condition of the patient may demand.

If the patient shows some evidence of shock from the operation and it be desired to stimulate him, a little ether may be poured

down the regulating tube into the reservoir from time to time; he will then inhale more ether than chloroform.

If oxygen be indicated, the tube from a cylinder of oxygen may be bent over into the air inlet of the reservoir, and the oxygen administered with the chloroform in this way.

For Use as an Ether Inhaler.—Place two ounces of ether in the reservoir, let the regulating tube rest in its highest position and fix upon its lower extremity the ring carrying the gauze petticoat before replacing the lid on the reservoir; the gauze should dip into the ether so that it will act as a wick and make the inspired air take up the maximum amount of ether vapour possible. Proceed with the administration as when chloroform is being given.

It is not recommended to *induce* etherisation by this—the open method, as the induction will take too long; better results are obtained by inducing anæsthesia with CE_2 mixture in this inhaler and, when full anæsthesia is established, substituting ether alone and conducting the administration in the manner described.

It will be found that larger quantities are used than with the closed method, but the patient has the advantage that he takes fresh air with every breath; there is no delimitation of oxygen; he is not subjected to the highly insanitary ordeal of breathing in and out of a small bag for a lengthened period; there is no cyanosis; no urgent respiration; little or no mucous secretion; and the anæsthesia resembles in every respect that usually seen under ACE. It therefore follows that unpleasant after-effects from the anæsthetic are less likely to present themselves, and that the recovery from an operation will be more satisfactory if the patient has not been partially asphyxiated during its performance.

The Dubois Apparatus while reliable as regards dosimentry is too cumbersome for anything but laboratory experiments. Furthermore, it costs over £20, weighing nearly 30 lbs.

However interesting this apparatus and experiments with them may be to physiologists, and however praiseworthy the end in view —viz. the lowering of the present high death-rate under chloroform —it is extremely unlikely that either will ever take a very important part in practical anæsthetics of the future.

It has been pointed out and proved with almost mathematical accuracy by Dr. Embley, himself an anæsthetist, that high percentage chloroform vapours cause vagus inhibition and death. It has been proved by means of Harcourt's and Dubois' machines that good anæsthesia can be *maintained*, if not rapidly induced, by means

of vapours of only 1 to 2 per cent. This is a most valuable piece of knowledge, and shows that the use of large quantities of chloroform with air exclusion is as unnecessary as it is extremely dangerous, and the person so employing chloroform culpable in the highest degree. But no piece of mechanism, however ingenious, can supply the lack of brains and skill in the medical man, and if an individual is incapable of learning to administer chloroform judiciously and properly by means of a drop-bottle and a piece of lint, it is unlikely that he will wield an apparatus like either of those we mention with safety to the patient, or satisfaction to himself or the operator.

Moreover, there are a number of valves, particularly in Harcourt's apparatus, which are very prone to get out of order, especially if the inhaler be only occasionally used. Any agitation of the bottle during the administration increases the strength of the vapour and upsets all the administrator's calculations based on the index, and quite recently a death very nearly occurred with Harcourt's apparatus in the hands of a skilled and practised operator.

The *raison d'être* of such an apparatus is, that it would give results in inexperienced hands better than we get at present with bottle and mask; but if accidents occur with those accustomed to the apparatus, what can we expect with the tyro?

Accordingly, the fact remains that while *any attempt to develop accuracy of dosage with chloroform is in the right direction*, by no means known to us at present can this valuable but lethal drug be rendered as safe as ether, ethyl chloride, &c., and especially is this the case in the early stage of any anæsthesia, when, as is well known, practically speaking, all the accidents occur.

The only means to ensure increased safety with anæsthesia is to raise the standard of education of medical men in this subject, and to encourage the use of ethyl chloride in minor surgery, and in the induction of anæsthesia for longer operations, in which the subsequent employment of ether, chloroform, or CE may be necessary.

APPENDIX B

FATALITIES UNDER ETHYL CHLORIDE

During the past year or two something of a "scare" has been worked up over ethyl chloride, and some well-known anæsthetists at the present time practically refuse to administer this drug. While one cannot altogether understand their attitude, there is no doubt that, in unskilled hands, it is an anæsthetic which should be used with a great deal of caution, both as regards dosage and length of administration.

The idea had got about among a large number of both the medical and dental profession that ethyl chloride is a sort of glorified nitrous oxide, which one can carry about in one's waistcoat pocket and administer to all and sundry without any special precaution or skill on the part of the administrator.

Nothing further from the facts of the case could be imagined, and the somewhat formidable list of fatalities below (in view of the youth of ethyl chloride as a general anæsthetic), which the author has been at some pains to get together, will, he trusts, go far to check the indiscriminate use of the drug. Its highly toxic character and the danger due to the great rapidity of its action should be fully recognised, as well as its admirable properties as an adjuvant to chloroform and ether. There can be no doubt about its value in this respect, but discrimination is required in regard to its use, as in many things. Beyond one or two cases of respiratory arrest—when the author first began using ethyl chloride—he has never seen any trouble from it in an experience of some two thousand cases, but he early recognised the necessity for small dosage, and great care and watchfulness in its administration.

1. Lotheisen's case. Male, aged 41. Alcoholic and cardiac disease. At Innsbruck. *Münch. Med. Wochenschr*, 18th November 1900.

2. Bossart's case. Child, aged 12 months. Suffering from diphtheria. At Aaran. *Correspond. Blatt. fur schweizer Aerzte*, October 1902.

3. Olcott Allen's case. Male, aged 28. Operation for hernia. Vomited a lot of fluid and died of asphyxia. *American Journal of Medical Science*, December 1903.

4. Female suffering from advanced dropsy. At Dublin. *Lancet*, 7th October 1905.

5. Male suffering from swelling in the neck. *Lancet*, 7th October 1905.

6. Male. Abscess in jaw. *Lancet*, 7th October 1905.

7. Male. Dental case. *Lancet*, 7th October 1905.

8. Male. A seaman at Haslar Hospital. Dental operation. *Portsmouth Evening News*, 24th April 1905.

9. Female, aged 50. At Stourbridge. *British Medical Journal*, 8th July 1905.

10. Female, aged 40. At Enfield. Dental case. "Somnoforme" was used. *British Journal of Dental Science*, April 1904.

11. Female, aged 42. Dental case. *British Journal of Dental Science*, 1st April 1904. Locality unrecorded.

12. A boy aged 10. Operated on for adenoids and tonsils at a Plymouth hospital. *General Practitioner*, 19th August 1905.

13. A death occurred during a dental operation at Llandudno in the summer of 1903.

14. A death occurred at Swansea in 1904, during a dental operation also.

15. A death occurred at Edinburgh in July 1905, during a dental operation. Patient, a delicate woman of 50 years of age.

16. A death occurred at a hospital in Edinburgh, also in July 1905.

17. Two fatalities occurred at Carlisle in 1905.

18. A death occurred in London in February 1906 in a dentist's house. See daily papers of that period.

19. A death occurred in a Bradford hospital in spring 1906, during a throat operation.

20. A death occurred in Oxford in January 1906.

21. A death occurred at Guy's Hospital in March 1906.

22. A death occurred in Leeds during 1905.

23 and 24. Two deaths occurred in the same year at the Mustapha Civil Hospital, Algiers.

A more detailed account of the majority of these fatalities will be found in a paper by the author in the *Lancet* for 12th May 1906. Since that date some six other cases have been here recorded.

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